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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 1031

Contribution from the Forest Service
WILLIAM B. GREELEY, Forester

Washington, D. C. ▼ May 15, 1922

RANGE AND CATTLE MANAGEMENT DURING DROUGHT

By

JAMES T. JARDINE, Inspector of Grazing, and CLARENCE L. FORSLING, Grazing Examiner

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WASHINGTON
GOVERNMENT PRINTING OFFICE
1922

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THE PROBLEM OF DROUGHT AND CATTLE PRODUCTION.

Cattle production on ranges of the Southwest in the past has been a business of "ups and downs," with prosperity or adversity governed by climatic conditions, which brought seasons of plenty in range forage and stock water followed by seasons of restricted forage growth and scarcity of water.

Soon after the cattle business became established on the open public range of the Southwest the herds were built up during a period of good years until the developed ranges were stocked fully or beyond the number that they could carry even in good years. Then, at in-

tervals, came dry periods, series of dry years, with much less forage produced than was required by the stock on the range and with heavy losses from starvation. During the early days, before all the ranges had been opened up, there was opportunity to develop new range in such an emergency and thus relieve the situation to some extent. Such possibilities diminished more and more, however, as practically all the range came into use, until there was little opportunity of this nature during the drought that ended in 1910, and practically none in the drought of 1916 to 1918.

The setback to the live-stock industry, caused by this combination of unfavorable climatic conditions and unwise range practice, comes about mainly through heavy losses of stock, low calf crop, interference with improvement of breeding herds, retarded growth of young stock, and range deterioration.

During the last drought, 1916 to 1918, according to estimates based on the best data obtainable, losses were at an average rate of 20 per cent annually for the three-year period and reached as high as 35 per cent in 1918, the worst year of the drought. Individual losses were as high as 50 per cent.

The large reduction in calf crop is probably next in importance to losses. The natural increase is the main source of income, and if greatly reduced at a time when expenses are high the result is serious. The calf crop for some of the ranges affected by the last drought was estimated at 35 per cent in 1917, 25 per cent in 1918, and 35 per cent in 1919, the three years most influenced by the drought. These figures are probably not far from representing the true situation.

Drought also has been a prime factor in retarding improvement in the grade of stock. Heavy losses and forced sales might wipe out years of effort in building up the herd or reduce the numbers to an extent that culling and selection necessary to maintain quality would not be consistent with the importance of increasing the herd to take advantage of good years, or the set-back might be such that it left the stockman financially unable to purchase the right kind of bulls.

Retarded growth and development of young stock is a consequence of the poor forage on the range in time of drought. This results in further decreased returns from the industry, due to lower prices being paid for stock taken, many steers being rejected by buyers and left on the range when they should have been removed to make as much range available as possible for cows, and heifers being stunted and thus requiring another year's growth before they would breed.

Range deterioration, or actual killing out of a part of the valuable forage plants, is one of the bad effects of drought which requires several good years to overcome. The extent of range deterioration

depends upon the duration of the drought and the manner of grazing. A study on the Jornada Range Reserve in southern New Mexico during the dry years of 1916 to 1918 showed that ungrazed range depreciated approximately 40 per cent as a result of natural conditions alone. The depreciation on grazed areas was according to the grazing. Range grazed heavily throughout the year deteriorated from 62 to 70 per cent in the stand of the best forage plants, while ranges not grazed heavily during the main growing season deteriorated as much as 45 per cent.

Many of the best ranges in the Southwest at the close of the last drought were 75 to 80 per cent below their original carrying capacity and will require several years of light stocking and careful management to restore them to even a reasonable condition as regards their carrying capacity.

If the production of live stock is to continue profitably over the vast area of the southwestern ranges the hazard of drought must be minimized. Ranges must not be allowed to deteriorate as they have in the past because of improvident grazing management, and measures for their restoration after drought must be provided for. The present losses of cattle must be cut down and the calf crops increased to more nearly what they should be. The breeding herds must be safeguarded against sacrifice sale and loss in time of drought, and young stock must be kept growing. The solution of the problem of stabilizing the production and reducing the hazards must take into consideration all these phases, and at the same time be capable of practical application to the every-day needs of the business.

Stockmen of this region realize that existing conditions are unsatisfactory. In a majority of cases, however, they are not in a position to apply the remedy, since they do not own the lands and can not regulate grazing upon them. If an individual stockman reduces his herd to save feed for emergency, the surplus grass tempts some one else to move his stock in and graze it. Supplemental feeding as a remedy is limited because of prohibitive cost.

Live-stock production in the southwest is dependent upon the range forage as the primary source of feed, and any remedy for existing conditions must, therefore, include a more conservative and wiser use of the range. The first requirement is centralized control which will regulate use of the range and prevent overstocking as well as insist upon better management plans for drought periods. Supplemental feeding can then be undertaken as far as good business will permit, and there will be opportunity for improvement of both stock and range.

The need for changes in the management of both range and stock, with adjustment especially to meet the trying conditions during periods of drought, led to the establishment in 1912 of the Jornada

Range Reserve [1] for a study of the problems involved. Investigations started soon afterwards are still in progress. Preliminary results were published in 1917.[2] The object of this publication is to present results to date, with special reference to the period of drought in 1916 to 1918, inclusive, and to outline the management and investigations proposed for the reserve in future based upon results and experience for 8 years, beginning in 1912.

JORNADA RANGE RESERVE.

The Jornada Range Reserve is an area of approximately 202,000 acres of typical semidesert range lying in a basin adjacent to the Rio Grande Valley in Dona Ana County, N. Mex., about 50 miles north of the Mexican boundary. The major portion of the area is a flat to slightly rolling plain varying in elevation from about 4,100 to 4,700 feet, with a small mass of igneous mountains, the Dona Anas, at the southwest corner. The eastern portion of the reserve, about one-fourth of the total, includes the western slope of the San Andres Mountains.

The locality is one of the most arid in the Southwest. Records for 57 years, at State College, N. Mex., about 15 miles south of the reserve, show an average annual precipitation of 8.60 inches, with precipitation for individual years as high as 17 inches and as low as 3.50 inches. The main rainy season occurs in July, August, and September, with an average of 4.50 inches during these three months. Temperature as high as 106° is common in summer, with almost continuous high winds, low humidity, and consequently high evaporation.

On the plains and foothills the soil [2a] shows an almost entire absence of humus, and there is no change in texture with depth, except such as may be purely geological. The lime content is very high, and a highly limy layer or "caliche" is characteristic. The development of this caliche layer is greatest under sandy or gravelly soils and least under the heavier clay soils.

On the plains light-textured soils, principally redish sand loams, loamy sand, and loose incoherent wind-blown soils predominate. On the rolling plain near the foothills of the mountains, areas of coarse gravelly soils are found, and in the center there are flats of

[1] The Jornada Range Reserve was created by Executive Order May 3, 1912, at the request of the Department of Agriculture, with the idea of securing a complete range unit for conducting experiments and demonstrations in range management under conditions existing in southern New Mexico and similar country in adjoining States. The boundaries were slightly modified by Executive Order Apr. 24, 1916, and at present include about 202,000 acres. Since May 1, 1915, the investigations have been made by the Forest Service of the Department of Agriculture.

[2] Jardine, James T., and Hurtt, L. C., Increased Cattle Production on Southwestern Ranges, U. S. Dept. Agr. Bull. 588, 1917.

[2a] Classification of soils on the reserve made by U. S. Bureau of Soils.

compact tight clay or "adobe." There is very little alkali land, except in the adobe lake beds, where water often stands until it evaporates.

The only water originally on the lands now within the reserve consisted of a number of mountain springs and intermittent lakes or flat depressions in the bottom of the valley.[3] Water for stock on plains range, both on the reserve and on adjacent range lands, is now pumped from deep wells by windmills and engines or is supplied by pipe lines carrying water from springs in the mountains and by tanks which catch and store flood waters. The reserve is now well watered, watering places for the most part being not more than 5 miles apart.

TYPES OF VEGETATION.

The greater part of the forage, perhaps 80 per cent, is furnished by perennial grasses, of which the most important are black grama, red three-awn or needlegrass, tobosa, dropseed, muhlenbergia, burro-grass, and alkali sacaton or saltgrass. Various brush species, among which mesquite, blackbrush, creosote bush, shadscale, sagebrush, and Mormon tea predominate, are found on the mesa or plain.[4]

Many species of both perennial and annual weeds, as well as various annual or "six-weeks" grass species, occur during the rainy season, but their duration is short and they do not furnish a great amount of forage.[5]

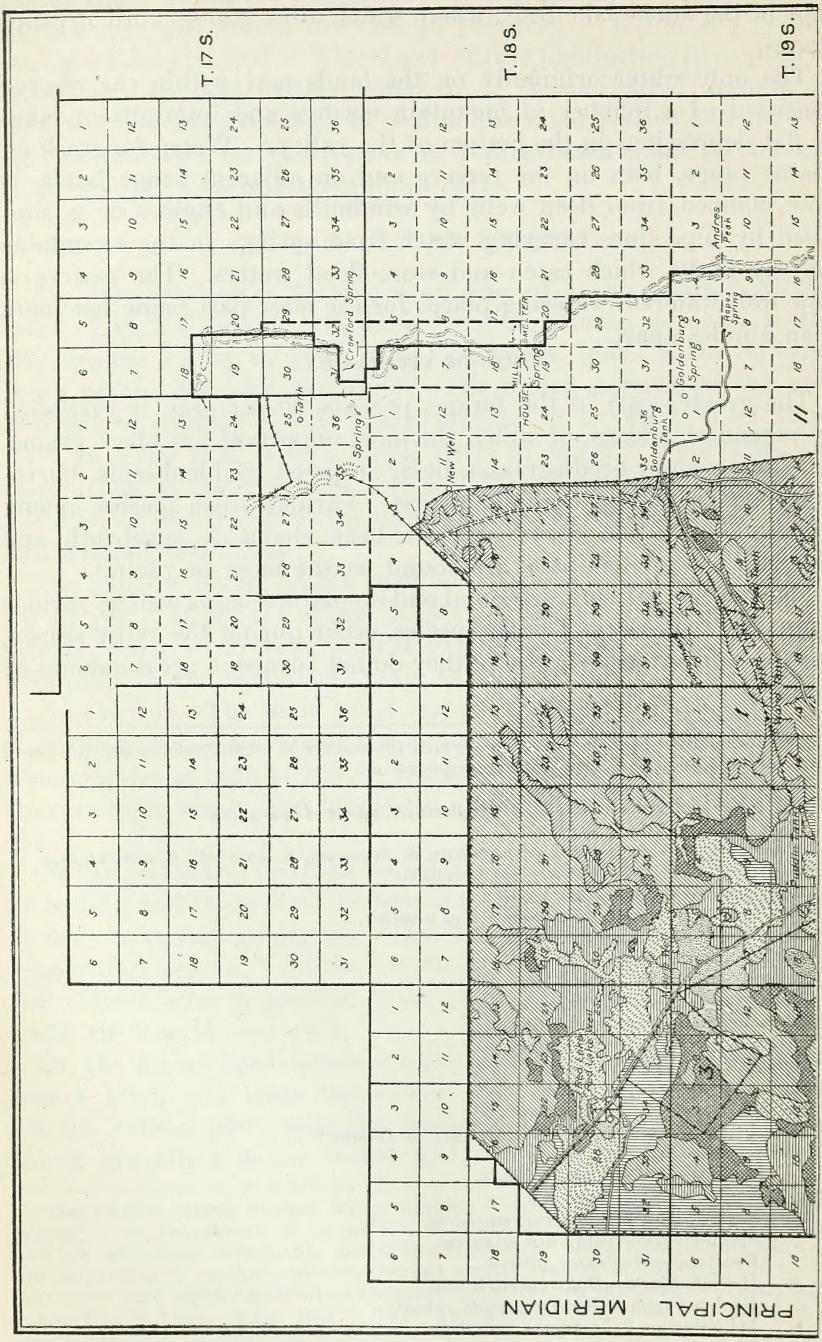
---

[3] The Jornada del Muerto plain, upon which the reserve is located, slopes gently toward a central depression or bolson with no drainage out.

[4] Black grama=*Bouteloua eriopoda.*
Red three-awn grasses=*Aristida longiseta, A. pansa, A. purpurea.*
Tobosa grass=*Hilaria mutica.*
Dropseed grass=*Sporobolus cryptandrus, S. flexuosus, S. wrightii, S. auriculatus.*
Ring muhlenbergia=*Muhlenbergia gracillima.*
Bush grass=*Muhlenbergia porteri.*
Alkali sacaton or saltgrass=*Sporobolus airoides.*
Burro-grass=*Scleropogon brevifolius.*
Low tridens=*Tridens pulchellus.*
Mesquite=*Prosopis glandulosa.*
Blackbrush=*Flourensia cernua.*
Creosote bush=*Covillea glutinosa.*
Snakeweed=*Gutierrezia furfuracea.*
Shadscale=*Atriplex canescens.*
Sagebrush=*Artemisia filifolia.*
Mormon tea=*Ephedra torreyana.*

[5] Some of the most important of these are as follows:
Perennials—
Baileya=*Baileya multiradiata.*
Spurge=*Chamaesyce* spp.
Leatherweed=*Croton corymbulosus.*
Spectacle-pod=*Dithyraea wislizeni.*
Evolvulus=*Evolvulus pilosus.*
Hoffmanseggia=*Hoffmanseggia* spp.
Hymenopappus=*Hymenopappus robustus.*
Yellowbush=*Psilostrophe tagetinae.*
Bushy senecio=*Senecio filifolius.*
Silvery nightshade=*Solanum elaeagnifolium.*
Whitestem=*Mentzelia multiflora* (mostly biennial).

(Footnote continued on page 8.)


T. 17 S.
T. 18 S.
T. 19 S.
PRINCIPAL MERIDIAN
Crawford Spring
Goldenburg Spring
Goldenburg Farm
Andres Peak
Tapia Spring
New Well
Mill
Tank
Spring
Trail
Road
Fence
Ranch
Cabin

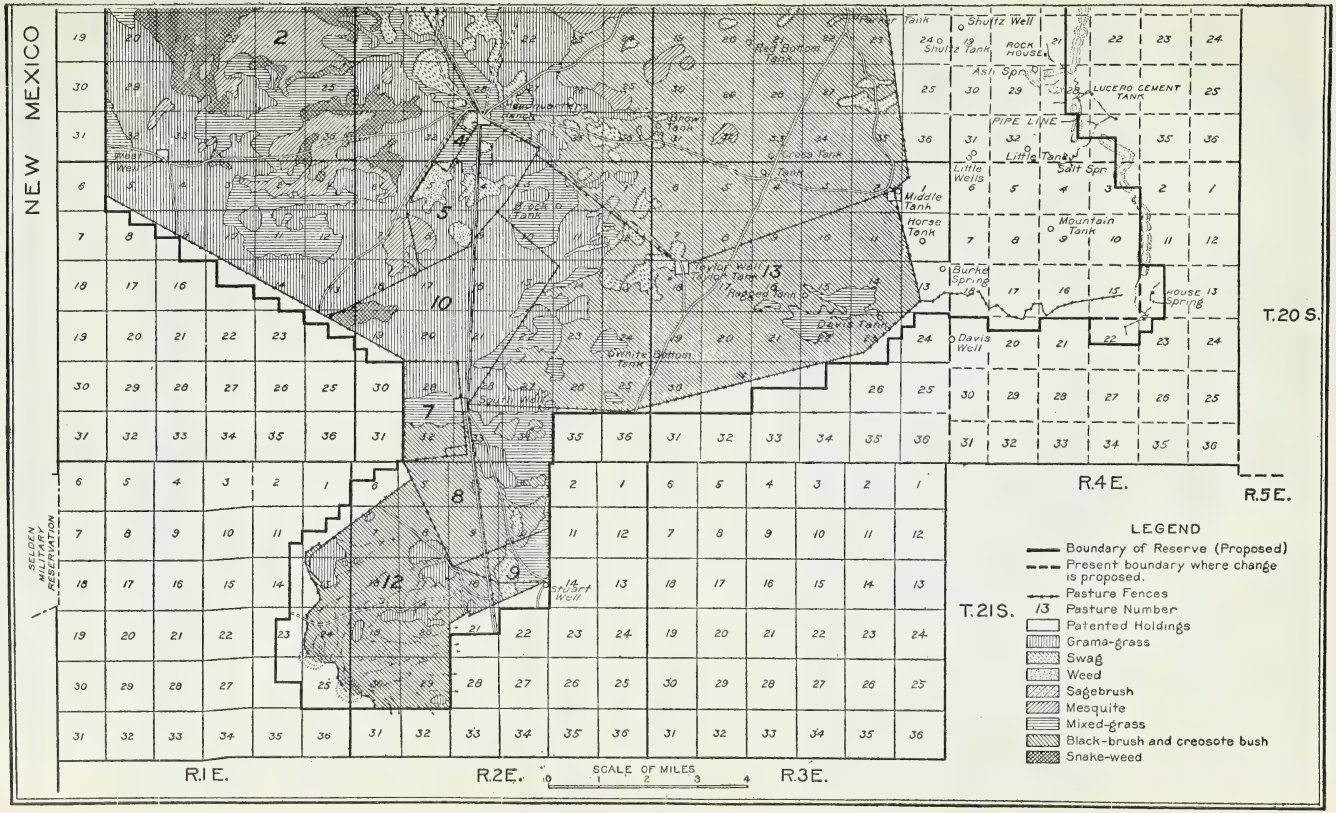


FIG. 1.—Map of Jornada Range Reserve.

The vegetation is more or less grouped into types. Figure 1 shows the vegetation classified into these range types for the plains of the reserve. Table 1 gives the acreage of each type by pastures of the reserve.

TABLE 1.—*Acreage by types and pastures of the plains area of the Jornada Range Reserve.*[1]

Pasture.	Grama-grass.	Snake-weed.	Mesquite sandhill.	Sage-brush.	Weed.	Swag.	Mixed grass.	Black-brush—creosote bush.	Total.
	Acres.	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*
1	3,416	1,438	31,730	8	894	5,393	[2] 5,472	26,363	74,714
2	14,473	4,834	5,922	423	721	1,658	[2] 6,514	.....	34,545
3	541	963	486	50	82	168	[2] 120	.....	2,410
5	1,497	.....	74	.....	461	286	[2] 497	.....	2,815
7	533	.....	.....	.....	.....	.....	[3] 408	509	1,450
8	315	.....	.....	.....	.....	33	[3] 1,255	2,427	4,030
9	.....	.....	.....	.....	.....	138	[3] 401	245	784
10	4,292	260	.....	.....	.....	.....	[3] 253	.....	4,805
11	746	.....	.....	.....	.....	68	[3] 52	6,183	7,049
12	1,538	.....	.....	.....	45	398	[3] 2,401	12,619	17,001
13									
Total	27,351	7,495	38,212	481	2,203	8,142	17,373	48,346	149,603

[1] Pasture No. 11 is not included. This is an area of approximately 52,317 acres of mixed grasses and browse types in the San Andres Mountains.
[2] Mixed-grass type in this pasture mainly grama, three-awn, and drop-seed grasses.
[3] Mixed-grass type in this pasture mainly burro, tobosa, and salt grasses.

Because of the time of the year during which the forage in the various types is palatable to cattle and the growth habits of the main forage species, the several types are divided into yearlong or winter range, and summer range. The grama-grass type, mixed grama, three-awn, and dropseed-grass type, snakeweed type, and mesquite-sandhill type constitute the yearlong or winter range, and the swag type, mixed tobosa, burro, and salt-grass type, and black-brush-creosote bush type make up the summer range.

YEARLONG OR WINTER-RANGE TYPES.

The grama-grass type (Pl. I, fig. 1) is the most important of the several yearlong or winter-range types. Black grama grass is the predominating plant species in this type, but other grasses, such as three-awn and dropseed occur to some extent. Soapweed [6] is the most conspicuous species next to the grama grass and is nearly always found in this type. Occasionally three-awn and dropseed grasses are more abundant than the grama grass, and in such cases form a mixed-

Footnote continued from page 5:
Annual weeds—
Boerhaavia=*Boerhaavia torreyana.*
Mouse ear=*Tidestromia lanuginosa.*
Eriogonum=*Eriogonum* spp.
Glandleaf=*Pectis angustifolia.*
Caltrops=*Tribulus terrestris.*
Six-weeks grasses—
Aristida bromoides, Bouteloua aristidoides, B. barbata, B. parryi.
[6] Soapweed=*Yucca elata.*

F-36842-A

FIG. 1.—BLACK GRAMA-GRASS RANGE IN SOUTHERN NEW MEXICO.

In good years there is abundant feed on this kind of range, but in time of drought the carrying capacity may be reduced as much as 50 per cent or more. Reduction of grazing 30 to 50 per cent of the year-long rate during the growing season is the main requirement for maintenance of grama-grass range.

F-43195-A

FIG. 2.—TOBOSA-GRASS RANGE ON THE JORNADA RANGE RESERVE.

The growth habits, compact soil it occupies, and low forage value after the growing season adapt this type of range to summer grazing. It is not easily killed out but carrying capacity is very low in time of drought.

F-151957

PASTURE 10 (LEFT), AND OUTSIDE RANGE (RIGHT).

Range on left was not grazed until after the growing season each year. That on the right has been heavily grazed yearlong for a number of years; much of the best grass has been killed and worthless weeds, especially snakeweed, are taking its place.

grass type. The grama grass occupies the more compact sandy soils, and this phase of the mixed-grass type the slightly looser soils.

The snakeweed type, although of minor importance, resembles the grama-grass and mixed-grass types in composition of forage plants, with the difference that snakeweed is the predominating species. There are also more weed species in this type, probably because the soil is a little looser than in the two types just discussed. Snakeweed is often an indicator of overgrazing, especially when it comes in on areas of better soil, but it also occupies a natural habitat of its own on the loose soils.

The mesquite-sandhill type has a very low density of palatable vegetation. It occupies more area than any other type on the plains areas of the reserve. Mesquite is the predominating plant species in the type, occurring in clumps which serve to catch blowing sand and thus to form the mounds or small sandhills. Other browse species occurring with the mesquite are shadscale and sagebrush, the sagebrush sometimes predominating on small areas to an extent that a distinct sagebrush type is formed. Both these species of brush are good forage for cattle, especially in winter. Grama grass, red three-awn, and dropseed grasses are the most important grasses found here, and, although they ordinarily occur sparsely, furnish the bulk of the feed in the type. A scattered stand of soapweed is characteristic of this type. Drifting of the soil occurs during high winds, and this makes it difficult for vegetation to become established from seed.

In all four of these types black grama grass is the most important forage species. The three-awn grasses and the various browse species are next in importance. These grasses are good forage when they are green, and they cure on the stalk on the range. The dry forage is readily eaten by stock. The various browse species in the mesquite type are grazed mainly during winter and spring. Consequently the grama-grass type and the other types in which grama grass or browse are the predominating forage species are important for winter and spring grazing, when there is little new growth, and the demand upon them for these seasons should be given first consideration. Also, since grama grass is the principal forage species in all of these types, their management should be based upon the growth requirements of grama grass.

SUMMER RANGE TYPES.

The swag or swale type (Pl. I, fig. 2) occurs on the low flat places of tight soils that are flooded from run-off in time of rains. Tobosa grass and burro grass are the only species of importance in this type.

Bordering on the swag type and on somewhat similar situations is a mixed-grass type in which occur mainly tobosa grass, burro grass, and saltgrass (given in the order of their importance).

The blackbrush-creosote bush type, composed mainly of a stand of these two brush species with an under cover of grass, occupies the level to slightly rolling area where clay to gravelly loam soils predominate. This type varies from the blackbrush phase with an under cover of tobosa grass, burro grass, and saltgrass on the more compact clay soil to the creosote-bush phase with bush grass, grama grass, and low tridens on the drier, more gravelly slopes and ridges. Although the latter are yearlong range grasses, the occurrence of this phase of the blackbrush-creosote bush type is too limited to segregate it from the summer range for grazing.

Tobosa grass is the most important forage plant in the three summer types, since it is the most palatable and abundant of the grasses and the brush species are worthless as forage. Soon after the growing season this grass becomes dry and unpalatable to cattle, and if not grazed before that time most of it is wasted. In fact fairly close grazing of this species is essential during the growing season; otherwise the dead material remaining interferes with utilization of new growth the following year. Close grazing during the growing season does not easily injure tobosa grass because of its underground method of revegetation, the compact soil it occupies, and the rapidity and rankness of its growth. The burro grass begins growth early and has its main value as forage before other vegetation has greened; after that time it is grazed but little. The saltgrass is another early feed, but, like tobosa grass, is of little value after it stops growth. These conditions and the high carrying capacity of the tobosa grass type make these three types ideal for summer grazing in the Southwest.

USE OF THE AREA PRIOR TO RESERVATION.

Prior to 1912 a number of individuals had attempted to develop water in wells and establish ranches on the land now within the reserve. The difficulty and cost of sinking deep wells, the prevalence of droughts, and severe losses discouraged the small owners and their range rights were eventually purchased by a single owner.[7] This

[7] The range rights on this area were purchased previous to 1911 by Mr. C. T. Turney, who is cooperating with the Forest Service in carrying on the studies. At the time of the creation of the reserve the 200,000-acre range unit was conceded to Mr. Turney by neighboring stockmen under common or range rights established by the purchase of prior rights and improvements of other owners and the construction of watering places on unused range. He leases all State lands and owns private lands around most of the wells. The Government furnishes the public lands under reservation. The experiments are planned by the Government and the stockman, and carried out according to agreement. All fencing, water development, and other construction work, as well as extra labor in handling stock for experimental purposes, are paid by the cooperator in lieu of grazing fees on the Government land. The Government furnishes the men to keep proper records of all experiments, to aid in the planning of new investigations, and to see that the work is properly conducted. Prior to the coming of Mr. Turney to this part of the county there had been no successful wells put down on the Jornada del Muerto plain except one very shallow well near Aleman, N. Mex. This broad expanse of dry plain even won

owner, who is the cooperator with the Department of Agriculture in the experiments, occupied part of the present area of the Reserve as open range and developed the first substantial permanent wells in the vicinity in 1904. With the exception of slightly better watering facilities due to development of several more wells and tanks on the area than on the average open range of the same size, the area was handled much the same as the average open range prior to the creation of the reserve, May 3, 1912. Stock grazed any part of the range yearlong, there was no provision for drought or to prevent overgrazing, losses and calf crop were about the same as elsewhere, and any attempts to improve the grade of stock were discouraging.

During the drought of 1908-1910 the experiences on the area now included in the reserve were similar to those that occurred on many other open ranges in that drought and in the drought of 1916–1918. Several good years had preceded the drought and in 1908 there were about 5,000 head of cattle on the 200,000 acres. In 1911, when the drought was over, only 600 head of cattle remained. The rest had starved to death or had been moved out to where range forage was available but the expense of returning them was not warranted. This is in contrast to the results presented in this bulletin for the same range under as bad or worse drought conditions, when the area was being handled under methods adjusted in part, at least, to preserve permanence in the industry through drought periods.

RECURRENCE OF DROUGHT.

The effect on the cattle business of the combined factors which together constitute what is generally understood as a "drought" has been outlined. The heavy losses, retarded growth of stock, low calf crop, heavy expense, range depreciation, and worry to the owners during such a period obviously warrant maximum effort to anticipate the recurrence of drought periods and the consequent reduction in range forage production. Records covering a period long enough to do this with certainty are not available, but an analysis of the rainfall and other records at hand and of past experience helps in explaining management later suggested to meet drought conditions.

Precipitation data for two stations—El Paso, Tex., and State College, N. Mex.—From 1886 to 1919, inclusive, except records which are lacking for State College in 1890 and 1891, are given in Table 2.[8] These data include the annual precipitation and the amount received

the name of Jornada del Muerto (the journey of Death) from the Spaniards in the early days because of the many people who had died of thirst in traveling over the area. It is here that the old Santa Fe trail came out on the plain, leaving the valley of the Rio Grande near Fort Selden because of the narrow, rocky gorge of the river farther north, and ran some 90 miles over the dry plain to a point just south of San Marcial, N. Mex.

[8] Data from Reports of the U. S. Weather Bureau and Bulletin 113, New Mexico College of Agriculture and Mechanic Arts, Climate in Relation to Crop Adaptation in New Mexico, by Charles E. Linney and Fabian Garcia, 1918.

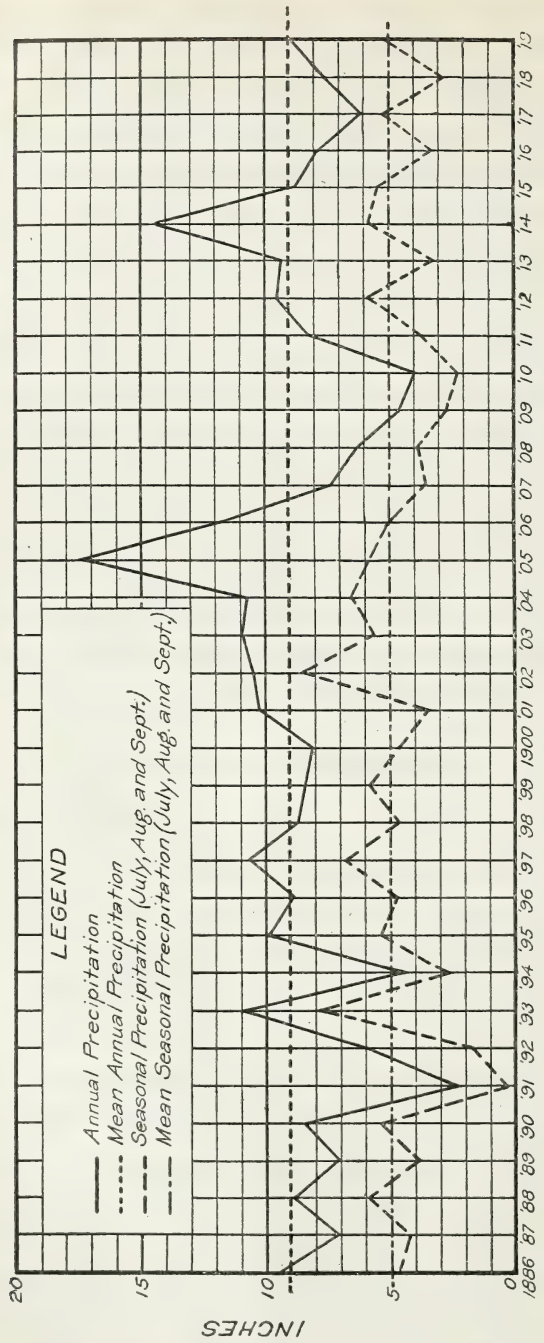

LEGEND
Annual Precipitation
Mean Annual Precipitation
Seasonal Precipitation (July, Aug. and Sept.)
Mean Seasonal Precipitation (July, Aug. and Sept.)
INCHES
20
15
10
5
0
1886 87 88 89 90 91 92 93 94 95 96 97 98 99 1900 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19

FIG. 2.—Annual and seasonal precipitation, State College, N. Mex., and El Paso, Tex.

during the main growing months—July, August, and September—and the departure above or below average for each year and season. Figure 2 shows these data graphically.

TABLE 2.—*Average annual and seasonal (July, August, and September) precipitation for two stations (El Paso, Tex., and State College, N. Mex.), and departures from normal.*

Year.	Annual rainfall.[1]	Departure from average.[2]	Seasonal rainfall.[1]	Departure from average.[2]	Year.	Annual rainfall.[1]	Departure from average[2]	Seasonal rainfall.[1]	Departure from average.[2]
	Inches.	*Inches.*	*Inches.*	*Inches.*		*Inches.*	*Inched.*	*Inches.*	*Inches.*
1886	9.50	0.48	**4.60**	**0.34**	1904	10.71	1.69	6.47	1.53
1887	**7.09**	**1.93**	**4.34**	**.60**	1905	17.44	8.42	5.88	.94
1888	**8.94**	**.08**	5.91	.97	1906	11.89	2.87	5.13	.19
1889	**7.08**	**1.94**	**3.87**	**1.07**	1907	**7.41**	**1.61**	**3.57**	**1.37**
1890	[3]**8.49**	**.53**	5.41	.47	1908	**6.45**	**2.57**	**3.98**	**.96**
1891	[3]**2.22**	**6.80**	[3].42	**4.52**	1909	**4.63**	**4.39**	**2.73**	**2.21**
1892	**5.92**	**3.10**	**1.73**	**3.21**	1910	**4.02**	**5.00**	**2.40**	**2.54**
1893	10.80	1.78	7.97	3.03	1911	**8.34**	**.68**	**3.78**	**1.16**
1894	**4.36**	**4.66**	**2.65**	**2.29**	1912	9.67	.65	5.96	1.02
1895	9.83	.81	5.47	.53	1913	9.41	.39	**3.28**	**1.66**
1896	**8.89**	**.13**	**4.75**	**.19**	1914	14.43	5.41	5.90	.96
1897	10.68	1.66	6.87	1.93	1915	**8.81**	**.21**	5.58	.64
1898	**8.68**	**.34**	**4.65**	**.29**	1916	**7.97**	**1.05**	**3.34**	**1.60**
1899	**8.48**	**.54**	5.87	.83	1917	**6.03**	**2.99**	5.23	.29
1900	**8.17**	**.85**	**4.60**	**.34**	1918	**7.72**	**1.30**	**2.95**	**1.99**
1901	10.32	1.30	**3.52**	**1.42**	1919	**8.96**	**.06**	5.04	.10
1902	10.52	1.50	8.56	3.62					
1903	10.96	1.94	5.67	.73	Average.	9.02	.....	4.94	.....

[1] Bold-faced figures represent years below average.
[2] Bold-faced figures for amount below average; other figures for amount above average.
[3] Data for State College lacking.

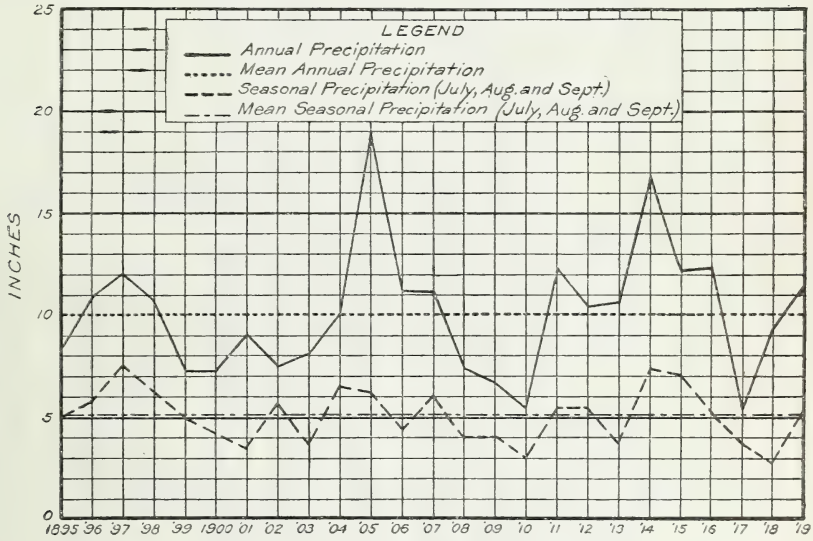


FIG. 3.—Annual and seasonal precipitation in southern New Mexico.

Owing to local variation in precipitation, figure 2, based upon records of two stations, represents only the general characteristics of southern New Mexico. Figure 3, based upon 24 years' (1895 to 1919, inclusive) records from seven stations (Table 3), although for a shorter period, covers slightly wider territory and is perhaps more representative of the semidesert ranges in New Mexico.[9]

[9] Data from Reports of U. S. Weather Bureau and Bulletin No. 113, New Mexico College of Agriculture and Mechanic Arts, Climate in Relation to Crop Adaptation in New Mexico, by Charles E. Linney and Fabian Garcia, 1918.

TABLE 3.—*Annual and seasonal (July, August, and September) precipitation for seven stations in southern New Mexico and vicinity with departure from the normal.*

Year.	Agricultural College.		Alamagordo.		Elephant Butte.		El Paso, Tex.		Lordsburg.	
	Annual.[1]	Seasonal.[1]	Annual.[1]	Seasonal.[1]	Annual.[1]	Seasonal.[1]	Annual.[1]	Seasonal.[1]	Annual.[1]	Seasonal.[1]
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
1895	9.47	6.18	.....	.....	**9.11**	6.47	10.20	**4.77**	**5.44**	**2.51**
1896	**7.99**	**4.21**	.....	.....	10.84	**6.04**	9.79	5.30	13.55	5.76
1897	8.96	5.55	.....	.....	16.89	10.40	12.41	8.19	13.33	9.70
1898	11.21	6.35	19.23	12.60	14.38	8.75	**6.16**	**2.96**	**6.13**	**2.63**
1899	9.67	7.12	.....	.....	**7.12**	**4.27**	**7.30**	**4.63**	**5.73**	**4.30**
1900	**8.40**	**4.22**	.....	.....	**6.03**	**3.97**	**7.95**	**4.99**	**6.99**	**4.34**
1901	11.96	4.83	**11.47**	**3.79**	**8.49**	**3.54**	**8.68**	**2.21**	**7.41**	**3.23**
1902	10.90	9.15	**7.25**	**5.30**	**6.19**	**5.36**	10.15	7.98	**5.87**	**3.80**
1903	10.29	4.90	**6.95**	**3.47**	**6.76**	**1.50**	11.63	6.44	**4.04**	**2.08**
1904	10.13	6.62	**8.95**	**4.92**	.....	8.80	11.30	6.33	**8.07**	5.30
1905	17.09	6.39	19.25	**5.07**	.....	.....	17.80	5.37	19.50	5.61
1906	8.80	**2.97**	**11.16**	**3.05**	.....	.....	14.99	7.30	9.58	**3.49**
1907	**6.42**	**3.33**	**10.88**	6.41	.....	.....	**8.41**	**3.81**	12.15	6.25
1908	**5.97**	**3.35**	12.11	7.62	.....	.....	**6.94**	**4.62**	**8.66**	**3.23**
1909	**4.94**	**2.74**	**6.85**	**3.64**	**6.68**	**5.33**	**4.33**	**2.73**	10.18	7.53
1910	**4.02**	**2.79**	**8.65**	**5.04**	**5.79**	**2.70**	**4.03**	**2.02**	**4.95**	**2.96**
1911	**5.80**	**2.68**	12.69	5.65	13.51	6.84	10.88	**4.88**	11.73	**3.54**
1912	9.20	6.22	**9.61**	**5.33**	10.95	**5.82**	10.14	5.71	14.15	6.33
1913	11.73	**4.30**	12.38	**3.93**	12.27	**4.40**	**7.09**	**2.27**	11.69	**2.51**
1914	11.85	**4.48**	19.03	7.43	15.12	7.68	17.02	7.32	19.70	7.69
1915	**7.37**	**4.67**	14.00	8.08	13.87	7.96	10.26	6.50	10.91	4.77
1916	**7.78**	**2.47**	12.46	**5.03**	13.73	**5.77**	**7.77**	**4.21**	.....	.....
1917	**5.58**	4.91	**5.20**	**3.97**	**3.53**	**2.85**	**6.49**	5.56	**8.28**	4.57
1918	**7.23**	**2.71**	**11.47**	**2.73**	10.76	**4.95**	**8.21**	**3.19**	.....	**.50**
1919	**8.05**	**4.20**	15.02	7.25	11.64	**5.15**	9.87	5.89	.....	.....
Mean	[3] 8.51	[4] 4.81	[5] 11.48	[5] 5.49	[6] 10.18	[6] 6.13	[7] 9.53	[7] 5.07	[8] 9.28	[9] 4.47

Year.	Socorro.		Deming.		Mean annual.		Mean seasonal.	
	Annual.[1]	Seasonal.[1]	Annual.[1]	Seasonal.[1]	Rainfall.[2]	Departure.[2]	Rainfall.[2]	Departure.[2]
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
1895	.....	.....	**8.23**	5.58	**8.49**	**1.52**	**5.10**	**0.09**
1896	.....	5.23	12.70	8.25	10.97	.96	5.79	.60
1897	**10.61**	5.52	10.21	6.17	12.07	2.06	7.59	2.40
1898	.....	.....	**7.42**	**4.25**	10.76	.75	6.25	1.16
1899	**7.71**	**4.36**	**5.74**	**5.24**	**7.31**	**2.70**	**4.99**	**.20**
1900	**7.05**	**2.70**	**7.41**	**5.28**	**7.30**	**2.71**	**4.25**	**.94**
1901	**10.06**	5.22	**5.37**	**1.93**	**9.06**	**.95**	**3.53**	**1.66**
1902	.....	.....	**4.66**	**2.87**	**7.50**	**2.51**	5.74	.55
1903	.....	.....	**9.09**	**3.25**	**8.12**	**1.89**	**3.61**	**1.58**
1904	.....	.....	12.53	7.31	10.20	.19	6.54	1.35
1905	**2.40**	10.12	17.59	**4.89**	18.98	8.97	6.24	1.05
1906	11.60	**4.31**	10.79	5.60	11.15	1.14	**4.45**	**.74**
1907	17.85	9.10	11.69	7.53	11.23	1.22	6.07	.88
1908	**6.29**	**2.63**	**4.50**	**2.19**	**7.41**	**2.60**	**3.94**	**1.25**
1909	**8.11**	**4.13**	**6.01**	**2.86**	**6.73**	**3.28**	**4.13**	**1.06**
1910	**7.62**	**2.84**	**3.42**	**2.78**	**5.50**	**4.51**	**3.02**	**2.17**
1911	16.12	5.53	15.10	9.20	12.26	2.25	5.47	.28
1912	**8.01**	**3.20**	11.13	6.04	10.45	.44	5.52	.33
1913	**8.10**	**2.37**	11.44	6.18	10.67	.66	**3.71**	**1.48**
1914	17.81	8.71	17.55	8.81	16.87	6.86	7.44	2.25
1915	16.57	10.34	11.88	7.85	12.12	2.11	7.17	1.98
1916	16.38	5.61	15.28	8.38	12.23	2.22	5.24	.05
1917	**4.69**	**3.02**	**3.40**	**2.30**	**5.31**	**4.70**	**3.88**	**1.31**
1918	12.22	**3.69**	**5.49**	**2.70**	**9.23**	.78	**2.92**	**2.47**
1919	16.31	6.02	**7.78**	**3.75**	11.44	1.43	5.37	.18
Mean	[10] 11.28	[11] 4.96	[12] 9.77	[12] 5.46	10.01	.....	5.19	.....

[1] Bold-faced figures for years below average; others average or above.
[2] Bold-faced figures for amounts below normal; other amounts above normal.
[3] 56 years' records.
[4] 57 years' records.
[5] 22 years' records.
[6] 26 years' records.
[7] 41 years' records.
[8] 35 years' records.
[9] 36 years' records.
[10] 23 years' records.
[11] 26 years' records.
[12] 42 years' records.

The period from 1904 to 1907 is remembered by stockmen of southern New Mexico as exceptionally favorable for the cattle business, and there was prosperity during the period from 1911 to 1916. They are still talking about the severe drought of 1908 to 1910, inclusive, and live-stock production has not yet recovered from the

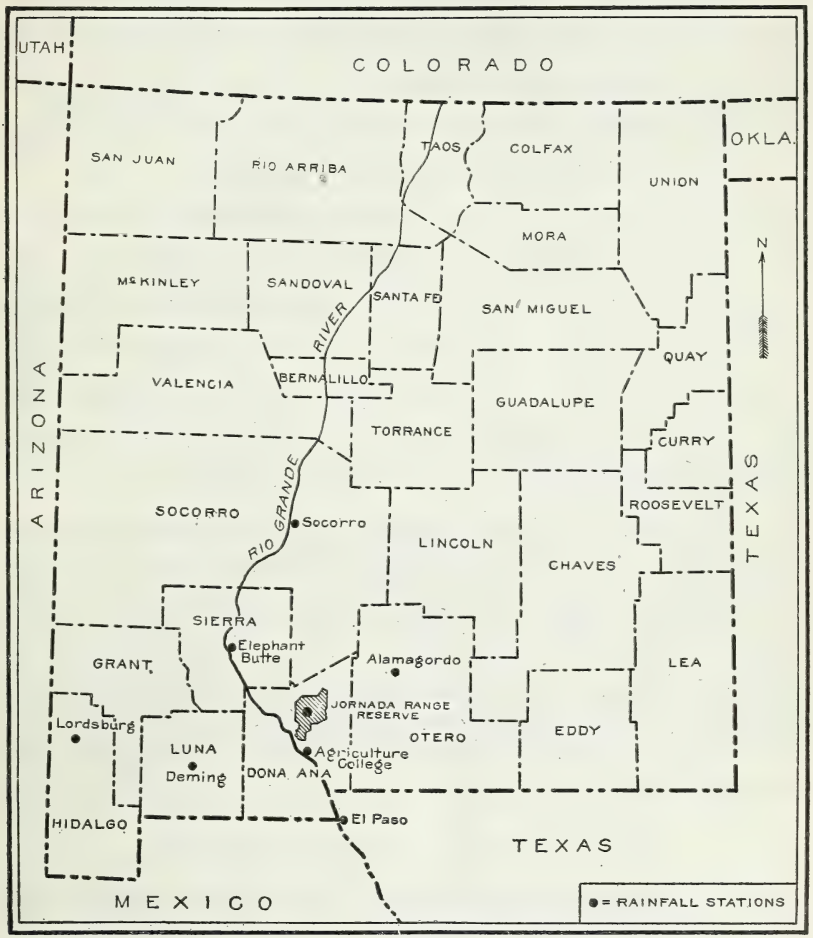


FIG. 4.—Map of New Mexico showing location of Jornada Range Reserve and rainfall stations.

drought of 1916–1918. Figures 2 and 3 show that the periods of prosperity in the business correspond to periods of approximately average or above in both seasonal and annual precipitation, and years of adversity to those below average. Figure 3 shows a similar dry period, from 1899 to 1903, inclusive, while figure 2 shows this dry period as from 1898 to 1901, inclusive. This difference is probably due to local variation in rainfall. Another similarly dry

period, 1889 to 1892, inclusive, with approximately average years back to 1886 is also shown in figure 2, and further records from the El Paso Station show exceptional precipitation in 1880 and 1884.

Further analysis of the precipitation data shows that for the years 1889 to 1892 the average annual precipitation was 34.1 per cent below the mean for the period 1886 to 1919; for 1899 to 1903 the departure below mean was 21.5 per cent; for 1908 to 1910, 34.6 per cent; and for 1916 to 1918, 10.9 per cent. During these same periods the average for the season July, August, and September was below the mean for these months for the whole period, 1886 to 1919, by 42.1 per cent in 1889 to 1892; 14.9 per cent in 1899 to 1903; 28.9 per cent in 1908 to 1910; and 22.8 per cent in 1916 to 1918.

Over 50 per cent of the mean annual precipitation falls during July, August, and September, and since the bulk of the range forage is produced primarily by perennial grasses which make their main growth during these months, it is not improbable that departure from mean precipitation for this growing season has a greater proportionate effect on the volume of forage produced and upon range maintenance than departure from mean annual precipitation. The effect of deficient precipitation during this period on the vegetation on the Jornada Range Reserve as later brought out seems to warrant this assumption.

For the present the main tentative deduction which seems warranted is that in cycles of 8 to 10 years there may occur 3 to 4 consecutive years during which precipitation is enough below the mean for the period to result in conditions considered by stockmen as drought. If future investigations can more definitely define the occurrence, duration, and intensity of these drought periods and the influence of seasonal precipitation, a big fundamental step will be made toward possible elimination of hazard connected with livestock production in this region.

PRECIPITATION ON THE JORNADA RANGE RESERVE.

Table 4 shows the precipitation by months, from 1914 to 1919, inclusive, with the exception of some data lacking in 1914 and 1915, for one station located at the headquarters ranch on the Jornada Range Reserve. Although rainfall in 1916 was slightly above the average for the year, there was a deficiency of 2.17 inches or 45.6 per cent departure from the average amount received during July, August, and September, the main growing season. The heavy rainfall occurring in October was too late for much benefit. During 1917 not only seasonal but annual precipitation as well was very deficient. In 1918 the amount of precipitation for the period of July, August, and September was not greatly below average for the region,

but the precipitation occurred in a few torrential rains during the latter part of July and early August, so that the moisture largely ran off and did not penetrate the soil to any great extent. Although vegetative growth started as a result of this precipitation, no more rains followed later in August or September, and a condition of drought actually existed until October over a large part of the reserve, as far as growing conditions were concerned.

TABLE 4.—*Monthly and annual precipitation for headquarters ranch station, Jornada Range Reserve, with departure from annual and seasonal (July, August, and September) average at State College, N. Mex.*[1]

[Bold-face figures indicate amount below average. T=trace.]

Year.	January.	February.	March.	April.	May.	June.	July.	August.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
1914	(2)	(2)	(2)	(2)	(2)	2.98	2.99	0.49
1915	0.49	1.12	0.95	0.09	(2)	**T**	1.40	1.91
1916	.25	.47	.79	.05	1.45	.00	.90	.96
1917	.47	**T**	**T**	.02	.39	.05	.57	1.52
1918	.78	.09	**T**	**T**	.05	.09	1.53	2.88
1919	.00	.00	1.50	.83	.28	.11	3.13	2.52

Year.	September.	October.	November.	December.	Total annual precipitation.	Departure from average at State College.	Total seasonal precipitation.	Departure from seasonal average at State College.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
1914	0.61	0.44	0.40	3.19	.....	.....	4.09	**−0.66**
1915	1.55	.00	.00	(2)	.....	.....	4.86	+ .11
1916	.72	2.63	.47	.19	8.88	+0.30	2.58	**−2.17**
1917	.25	.11	.16	.00	3.54	**−5.05**	2.34	**−2.41**
1918	.00	.96	1.71	.67	8.76	+ .22	4.41	**− .34**
1919	2.55	.64	.72	.50	12.78	+4.20	8.20	+3.45

[1] Data at Jornada Range Reserve station are compared with average at State College, since sufficient years' data are not available at Jornada Range Reserve for obtaining a reliable average over a period of years. The State College station is only 17 miles south of the reserve station, and about 300 feet lower in elevation, so that conditions are considered sufficiently similar to use the State College figures for comparison.

[2] Data lacking.

Average annual precipitation at State College, N. Mex. (59 years records)=8.58 inches; average seasonal precipitation at State College, N. Mex. (59 years, records)=4.75 inches.

The conditions as shown by the rainfall data at the one station on the reserve are fairly representative for the reserve as a whole. Some parts, however, received more rainfall during the growing season and others received less.

Uneven rainfall.—Within the territory represented by any of the stations for which precipitation records are given there may be great variation in the amount of precipitation on different portions of a single large range unit, or on different range units in any year or during the period of a drought. This variation results in a minor factor of uncertainty in anticipating what forage production may be expected on any given area, and necessitates a flexible general

plan of management in order to avoid local overstocking to the detriment of stock and range.

The possible extent of this local variation in precipitation is apparent from observations at the Jornada Range Reserve and vicinity from 1915 to 1919. In 1918 four additional rain-measuring stations were established on the reserve at distances of 7 to 13 miles apart. Table 5 shows precipitation at these stations in addition to the headquarters and State College stations.

TABLE 5.—*Annual and seasonal (July, August, and September) precipitation for New Mexico State Agricultural College and five rain stations on the Jornada Range Reserve, showing variation in amount within comparatively short distances.*

Year.	Agricultural College.		Headquarters.		South Well.		Red Lake.		West Well.		Ropes Spring.	
	Annual.	Seasonal.	Annual.	Seasonal.	Annual.	Seasonal.	Annual.	Seasonal.	Annual.	Seasonal.	Annual.	Seasonal.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
1915	7.37	4.67	[1] 7.51	4.86	.....	.....	.....	.....	.....	.....	.....	.....
1916	7.78	2.47	8.88	2.58	.....	.....	.....	.....	.....	.....	.....	.....
1917	5.58	4.91	3.54	2.34	.....	.....	.....	.....	.....	.....	.....	.....
1918	7.23	2.71	8.76	4.41	5.47	2.39	7.06	3.88	5.87	3.16	8.89	3.70
1919	8.05	4.20	12.78	8.20	7.72	4.67	11.52	6.42	7.91	4.96	16.37	5.85

[1] Approximate.

Although no precipitation records are available, it is known from observations that the range unit adjoining the reserve on the south received more precipitation during 1917, a year of the recent drought, than fell on the reserve. In 1919, however, it probably received less precipitation than the reserve by an amount sufficient to make a difference in the current year's forage and in recuperation of range. The range unit north of the reserve received earlier rains and a greater total precipitation than the reserve in 1918 and 1919, a difference of sufficient importance to warrant a change from the prearranged plan of grazing the unit.

This possible variation is pointed out merely as one of many warnings against too heavy stocking of a range unit as a whole or a plan of management which is not reasonably flexible to meet such a situation by shifting stock from a local dry area to one of more abundant rainfall without disarranging the whole plan.

VARIATION IN FORAGE PRODUCTION.

Some measure of the volume of range forage which may be figured on seasonally, annually, and over a period of years, and the main factors responsible for variation, are fundamental in deciding the classes, numbers, and management of live stock. Drought and im-

proper grazing will be agreed to readily as the major factors responsible for variation in forage production. Other factors, such as "spotted" rainfall, soil, and character of vegetation necessitate adjustments in any general program of production. These adjustments are of little purpose, however, unless they are part of a comprehensive plan calculated to meet the conditions resulting from drought and from grazing use.

VARIATION DUE TO DROUGHT.

It is somewhat difficult to determine from data available the percentage of depreciation of the range as a direct result of drought, because records of changes in vegetation on areas protected against grazing have been collected only for the period 1915 to 1919, inclusive, and because part of the protected areas being studied were rendered unreliable by sand blowing on them in amounts sufficient to create unnatural conditions. However, the data available are important because they show, at least approximately, the changes which occurred in the main vegetation types during the drought of 1916 to 1918, and indicate the changes which will probably occur during a similar period in future years.

WINTER OR YEARLONG RANGE.

For the winter or yearlong type of range figure 5 indicates the annual change in density of good perennial forage grasses during the period 1915 to 1919, inclusive, with the annual precipitation for the same period. The actual amounts of good perennial forage grasses, inferior perennial grasses, long-lived weed[10] vegetation, and short-lived plants per unit of area are given in Table 6. Only the good perennial forage grasses, mainly black grama and red three-awn, are used in establishing the curve indicating the change in condition of the vegetation, since these species represent the main grazing values of the range and are the ones most important to maintain. The vegetation curve is based upon quadrat chartings and observations on two representative areas of grama grass range, one protected against grazing from 1913 to 1919 and one protected from 1916 to 1919, inclusive. The protected areas were examined frequently each year, and quadrats were charted twice annually in 1915 to 1919, except 1918, when only one charting was made because of lack of vegetative growth early in the year.

[10] "Weeds" as used in this publication mean all herbaceous vegetation other than grasses or grasslike plants.

TABLE 6.—*Amount and class of vegetation on inclosures protected from grazing and percentage of maximum stand, 1915 to 1919 inclusive (grama grass type).*

Year.	Good perennial forage grasses.		Inferior perennial forage grasses.		Long-lived perennial weeds.	Short-lived weeds and annual vegetation.
	Square centimeters [1] per square meter.	Per centage of maximum stand.	Square centimeters [1] per square meter.	Per centage of maximum stand.	Number plants [2] per square meter.	Number plants [2] per square meter.
1915	511	87.6	7	80	2.6	44.4
1916	583	100.0	8	90	3.0	33.0
1917	[3] 537	92.1	7	80	17.5	61.5
1918	511	87.6	9	100	2.0	82.5
1919	347	59.5	8	90	0.0	31.5

[1] Actual measurement of area of grass tufts in square centimeters 1 inch above the ground on each square meter. (The metric system, with area expressed in square centimeters per square meter instead of with feet and inches, was used for convenience in the study because a unit of measure less than a square inch was necessary.)

[2] Actual count of number of individual plants per square meter.

[3] Actual measurement showed 699 square centimeters but contained a considerable amount of dead forage mixed in with the living plants. This dead forage was estimated from best method of determination to be 23 per cent of total stand of vegetation.

Change in density of the grasses did not conform immediately to change in the rainfall. The main reason for this is the fact that the vegetation is dependent more directly upon available soil moisture than upon current precipitation, and the soil did not dry out to such a degree that it affected the growth so materially the first year of drought. In addition, however, the vegetation gradually decreased in vigor and resistance to unfavorable conditions, and further, there was difficulty in determining the percentage or total of dead grass until 1919. By 1917, the second year of the drought, the soil was becoming quite dry and the vigor of the grass had been considerably reduced. In 1918 the soil was so dry that a more nearly average rainfall occurring over a short period during the middle of the growing season did not materially improve growing conditions, and the weakened vegetation continued to die. In 1919 soil moisture was materially increased, but in the 1919 examinations considerable grass was found to be dead which had been classed as living in previous examinations. There was difficulty in determining the grass actually dead in 1918 on account of the absence of green growth and persistence of dry growth from previous years. In 1919, however, the dead growth had largely disappeared and the records are considered a reliable index of living vegetation.

The vegetation appeared to have reached its low point prior to the 1919 examination. Comparison of the conditions in 1919 with those of 1916, therefore, give the extent of range deterioration as a result of the drought on grama-grass areas not grazed. This depre-

ciation, amounting to 40.5 per cent, is believed to be approximately representative of the average depreciation of grama-grass range on

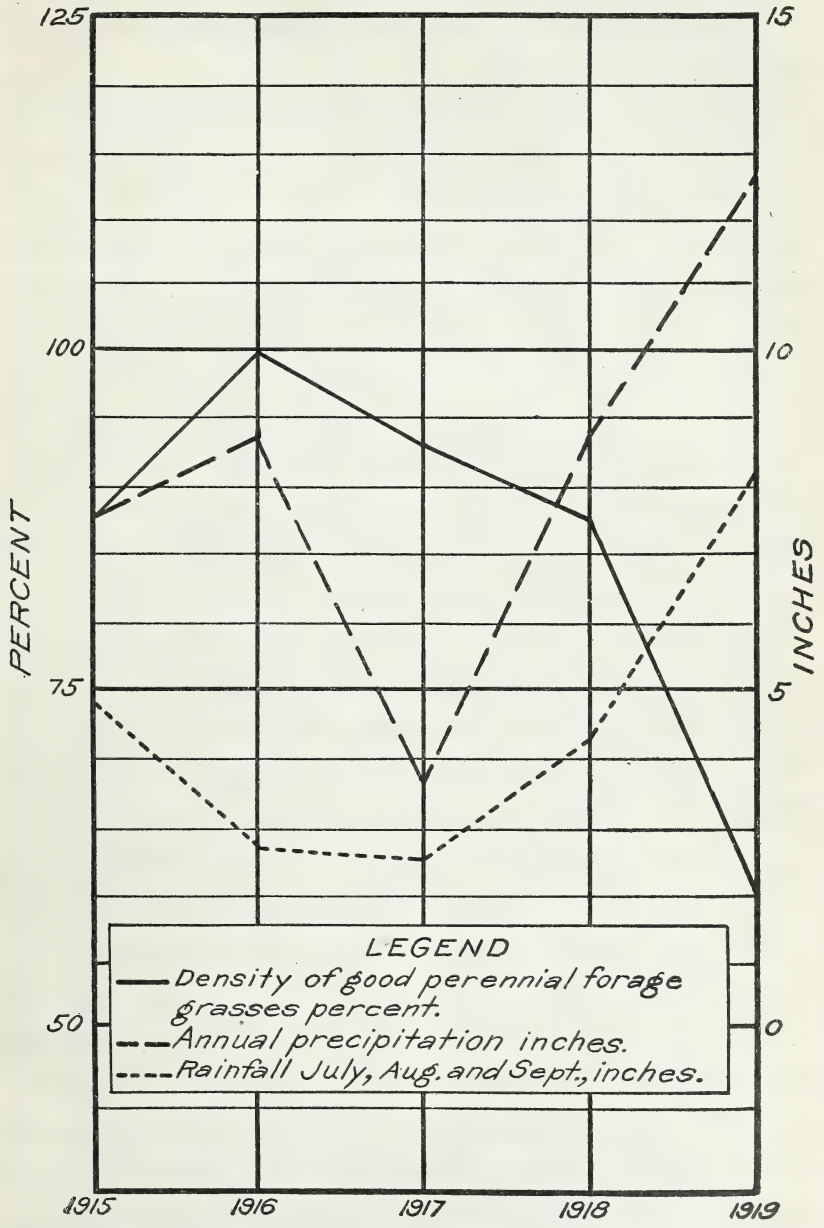


FIG. 5.—Density of good perennial forage grasses, on protected grama-grass range compared with annual and seasonal precipitation at the reserve.

the Jornada Range Reserve due to drought, although there is considerable variation. Plate II shows how this grass was killed out.

Areas of loose sandy soil dried out more quickly and were subject to greater injury than areas of the more compact finer textured soils. The difference was increased by the action of wind as well as difference in soil and moisture. Local areas of loose sandy soil were reduced to wind-blown wastes.

Because of the small amount of inferior grasses and long-lived perennial weeds on the two areas under study a conclusion as to the behavior of such vegetation is not warranted. This class of forage is not of great value except during wet springs, when it furnishes considerable early feed.

Vegetation of the character that usually lasts but a single year is not so materially affected by drought, because the plants depend upon the surface soil for their moisture, which might be supplied by showers at the proper season of the year, even during drought. The largest number of such plants occurred during 1917 and 1918, the driest years of the drought. This might easily occur, since the high winds increased dissemination and planting of the seeds, the rain that fell was sufficient to moisten the surface soil to promote growth, and competition by the main grasses had diminished. The volume of forage furnished by this kind of vegetation on range used in winter is negligible, however, since the plants dry up and blow away soon after the growing season.

Aside from the reduction in density of the forage stand due to drought, there was also a reduction in the height and foliage growth which further reduced the volume of forage. In 1917 the average height growth of ungrazed grama-grass was 13 inches, in 1918 it was only 8.6 inches, while in 1919, a year of more moisture, the average height growth reached 16 inches. It was difficult to measure in actual terms of quantity the difference in volume of forage produced due to variation in height and foliage growth on the ungrazed plots, because the previous year's foliage was not removed and the dryness of the plants made it difficult to determine the amount that was actually dead. Careful estimates, however, placed this reduction in 1917 and 1918 in volume of forage produced per unit area of vegetative stand at not less than 20 per cent of the amount produced under average condition. More nearly average height growth and foliage production was reached in 1919 by the plants that survived the drought.

From the grama-grass range under protection against grazing the data and estimates indicate a reduction in the stand of the most important forage plants of 8 per cent in 1917, 12.4 per cent in 1918, and 40.5 per cent in 1919, as compared with the stand in 1916. One of the plots observed had been under protection since 1913, the other since 1915, so that the stand in 1916 was probably near the maximum for the two sites which were chosen as representative of this type of

range. The figures for 1917, and especially for 1918, however, may be too low, because of the difficulty of determining under the dry con-

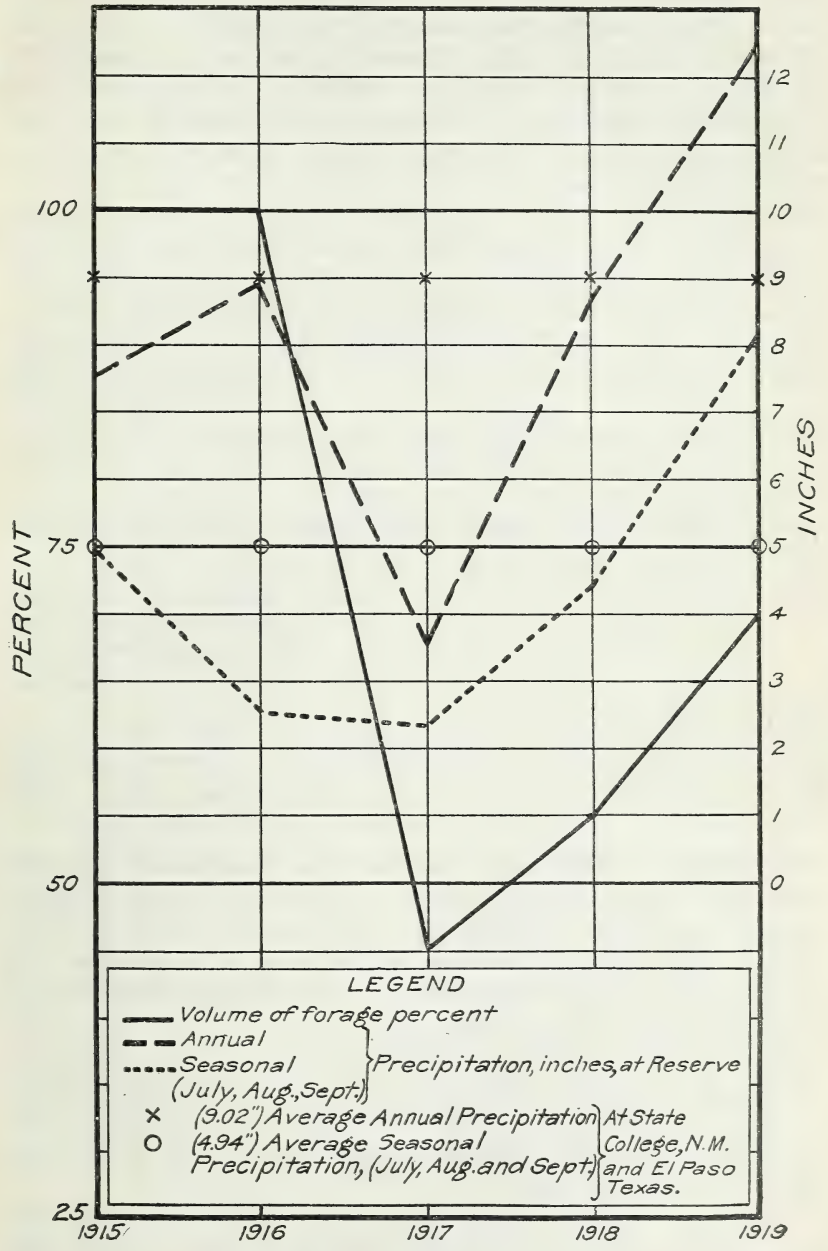


FIG. 6.—Volume of forage on tobosa grass, summer range, compared with precipitation.

ditions prevailing just what plants were dead; but the reduction to 59.5 per cent of the original stand in 1919 is believed to represent the

actual amount of living forage. It is undoubtedly true, however, that depreciation is much greater in the third year of drought than in either the first or second year, on account of the increased desiccation of the soil and lowered vitality of the vegetation. Adding to this depreciation in stand the estimated 20 per cent decrease in volume due to decrease in height and number of leaves produced per living plant in 1917 and 1918, the volume of forage by years was about 100 per cent in 1916, 73.6 per cent in 1917, 70.0 per cent in 1918 and 59.5 per cent in 1919.

Summer range.—Table 7 and figure 6 show what occurred in the density of vegetation on the main summer range type during the drought on a representative area protected from grazing during the summer and fall of each year. Since at other times of the year forage on this type is of low palatability and therefore but lightly grazed, the area used is representative of yearlong protection. The quadrat on this area was charted and observations made annually, with the exception of 1917, when the vegetation was too dry to chart and only observations were made.

TABLE 7.—*Amount of vegetation, percentage of maximum stand, and percentage of maximum volume of forage on tobosa-grass range, 1915 to 1919.*

Year.	Amount of grasses (square centimeter) per square meter.	Percentage of maximum year.	Volume of forage produced, in percentage of maximum year.
1915	928	100.0	100.0
1916	928	100.0	100.0
1917	930	100.0	45.0
1918	935	100.0	55.0
1919	656	70.1	70.1

The density of the forage on the tobosa-grass range remained practically stationary during 1916, 1917, and 1918, so far as it was possible to determine. During 1919, as the result of the accumulated effect of the drought, it decreased 30 per cent. It is probable that part of the 30 per cent died prior to 1919, although final removal of dead grass did not occur until 1919.

Height growth and foliage production were reduced about 55 per cent in 1917 and 45 per cent in 1918, but were approximately average in 1919. Considering the volume of forage in 1916 as 100 per cent, the estimated volume in 1917 was 45 per cent; in 1918, 55 per cent; and in 1919, 70.1 per cent.

The results from the study of the tobosa or summer-range type show a greater reduction in volume of forage produced in dry years as compared with protected grama-grass range, but density of the

stand in the tobosa type is not decreased nearly so much in time of continued drought as in the grama-grass type. Furthermore, improvement of the tobosa type is likely to occur immediately with the first wet year, while in the case of the grama-grass type several years will probably be required for this recovery. The great reduction in volume of forage produced in the tobosa-grass type in a dry year appears to be due to a greater moisture requirement for growth than in the case of the grama type species. The lesser reduction in density of the stand in the tobosa type in time of prolonged drought is evidently due to the ability of these species to lie dormant longer without moisture before dying than is grama-grass, and to a finer-textured and more compact soil which has a greater air-dry moisture content than the looser sandy soils of the grama-grass type. Although tobosa-grass probably has a greater drought resistance, the volume of forage produced is affected more directly by the amount of moisture that falls.

Studies of tobosa-grass areas fully grazed during summer showed approximately the same depreciation on these as on areas not grazed, which indicates that this type of range can be grazed fully during the growing season without injury in time of drought as well as in good years. The main difficulty with this type in time of drought is the big decrease in foliage production rather than killing out of the range, as shown in figure 6.

VARIATION DUE TO GRAZING.

The preceding discussion is intended to bring *out the amount and variation in forage production on certain areas of the* Jornada Range Reserve *protected against grazing.* This measure of natural production indicates the maximum forage which will probably be available for use over a period of years under natural conditions, and is a standard with which to compare production on similar ranges under different grazing use so as to adjust grazing in a way which will maintain the range and support the maximum stock over a period of years, including drought. A comparison of this nature has been made for the period 1915 to 1919, inclusive. The conditions studied include ranges where grazing has been excessive yearlong for a period of years, where grazing has not been too heavy for the year as a whole but only during the main growing season, and where grazing has been heavy for the year as a whole but much lighter than average during the main growing season. A description of the areas and how they were grazed, with the results and conclusions, is here presented.

OUTSIDE RANGE.

Adjoining the Jornada Range Reserve on the west is an area of about 98,530 acres, of which about 66,485 acres are the grama-grass type. The remainder is primarily of mixed-grass type of less grazing value than the grama grass. This area is controlled by private individuals and was used to study unregulated grazing as compared with regulated grazing on the reserve. Potentially, this range is as good as the protected plots on the reserve or better, as is indicated by the density and kind of vegetation at points so remote from water that stock have rarely ever more than lightly grazed it.

In 1915 this outside range supported on the average only 45.4 per cent as much good forage grasses as similar range in about maximum condition under complete protection against grazing. Of inferior grass forage, however, the outside range had 14 times as much as the protected area. The amount of other vegetation did not differ greatly. As a whole, the outside range was considered in condition about 50 per cent of the maximum under average growing conditions, when the drought began in 1916. This state of depletion was attributed to yearlong overstocking, over a period of years previous to 1916.[11]

Heavy yearlong grazing was continued on this area during 1916–17 and the early part of 1918. In the spring of 1918 and during 1919, however, it was almost completely protected against grazing during the main growing season, July 1 to October 1, and the forage was fully utilized during the remainder of each year, but the area was not overstocked.

PASTURE 2 OF THE JORNADA RANGE RESERVE.

Pasture 2 of the reserve contains about 34,545 acres adjoining the outside range described on the east. It is primarily grama-grass range. This pasture had been lightly grazed during the main growing season and slightly undergrazed for the year as a whole, for three years prior to July 1, 1916, as shown by Table 8, and under this management had improved about 50 per cent as compared with similar range grazed year long. In 1915 pasture 2 was considered slightly better in amount of forage per unit of area than the protected areas, and almost as good as the maximum later reached by the protected areas.

[11] Fully discussed in Department of Agriculture Bulletin 588.

TABLE 8.—*Rate of stocking during year, percentage of reduction of stocking during growing season, percentage of utilization of forage, and reduction in forage stand in pasture 2, 1913 to 1919.*

Year.	Actual acres per cow year long.	Percentage reduction in average yearly stocking from 1913 rate.	Percentage decrease or increase in grazing during growing season compared with yearly average.	Percentage utilization of forage at close of grazing season.
1913	26.6		−35.3	100
1914	47.0	43.5	−62.1	57
1915	33.1	19.8	−30.8	80
1916	43.9	39.3	02.6	90
1917[1]	44.3	40.1	44.6	125
1918	90.2	71.5	36.1	90

[1] 82,900 pounds of cottonseed cake were fed to stock in this pasture in the spring of 1918. While this feeding served largely to keep cattle from getting too poor it allowed utilization approximately 25 per cent above estimated proper rate of stocking.

Table 8 shows that this pasture was stocked at approximately the annual yearlong rate during the growing season of 1916, but that during 1917 and 1918 stocking was considerably heavier during the growing period at this season than for the year as a whole.

PASTURE 5 OF THE JORNADA RANGE RESERVE.

Pasture 5 of the reserve is an area of 2,815 acres primarily of good grama-grass range. In the spring of 1915 this area was about 44 per cent below what it should have been, and deterioration was attributed largely to overstocking during the main growing season for several years previous. In 1916 the average number of stock in this pasture was reduced 35.5 per cent, with a slightly greater reduction during the growing season; in 1917 the average number of stock was reduced 33.8 per cent from the rate during 1915, and 54 per cent during the growing season; in 1918 the average for the year was again heavier than the 1915 stocking, but during the growing season grazing was less than 50 per cent of the average for the year.

RESULTS OF THE VARIOUS DEGREES AND PERIODS OF GRAZING.

The effects of the condition of drought prevailing and different time and degrees of grazing practiced on the various areas are shown in Table 9 and compared graphically in figure 7.

Under the conditions of drought and grazing prevailing during 1916 the outside range about held its own as compared with 1915, but it deteriorated 21.5 per cent in 1917 and 39.9 per cent further in 1918. In 1919 there was a slight but real gain in conditions, so that the total deterioration during the drought period was about 60 per cent as compared with the condition of this range in 1916. The

slight improvement in 1919 is attributed to the protection from grazing during the growing season in 1918 and 1919. As compared with

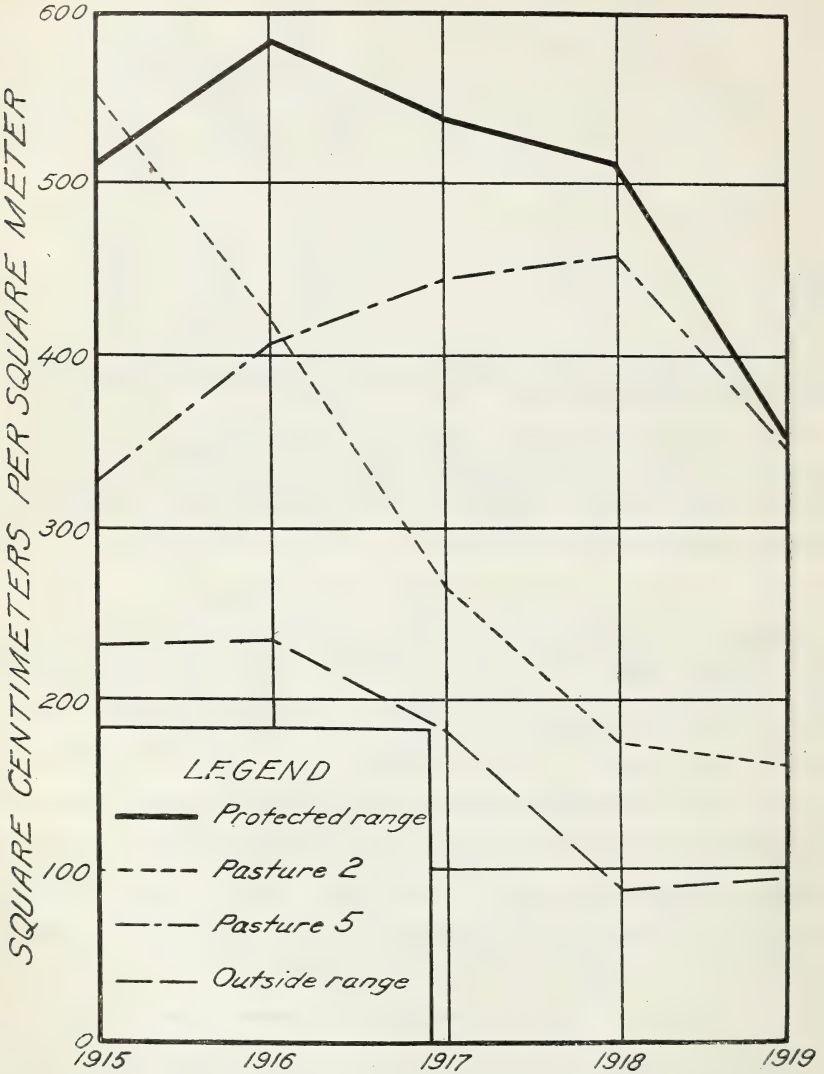


FIG. 7.—Comparison of density of good grass forage on outside range, pasture 2, pasture 5, and protected range, 1915–1919.

NOTE.—Pasture 2 was in good condition in 1915 as a result of protection during main growing seasons of 1913–1915. Grazing was not reduced during main growing seasons 1916–1919. Pasture 5 was run down in 1915 as a result of previous improper grazing. It received light grazing during main growing seasons 1916–1919 with full use rest of the year. Outside range was badly run down in 1915 as a result of previous improper grazing. Heavy yearlong grazing continued till 1918. Light grazing prevailed during growing seasons 1918–19.

the amount of forage on the protected areas in 1915 the outside range was only 45.4 per cent as good that year and only 17.6 per cent as

good in 1918. The slight improvement of this range during 1919 and continued deterioration of the protected areas made the former 27.1 per cent as good as the latter that year. This difference in action on the two areas in 1919 is attributed to the fact that the protected areas with over 80 per cent of a maximum stand had more vegetation than the available moisture would support, and the result was heavy depreciation. On the other hand, the outside range, with less than 30 per cent of a maximum stand and approximately equal average moisture conditions, made improvement when protected during the main growing season for two years. This conclusion is supported by the records given later for pasture 5.

TABLE 9.—*Variation in density of grama grass on protected areas, outside range, pasture 2, and pasture 5, and comparison of grazed ranges with protected areas, 1915 to 1919, inclusive.*

Year.	Protected areas—Range protected from grazing yearlong.		Outside range.—Range heavily grazed yearlong until 1918; very light grazing during growing season in 1918 and 1919.		Pasture 2—Range grazed yearlong without overgrazing, but no reduction in grazing during growing season after 1915.		Pasture 5—Reduced grazing during growing season since 1915 but fully utilized during the rest of the year.		Percentage of forage on grazed range as compared to protected range each year.		
	Amount of grass, square centimeters per square meter.	Percentage of maximum year.	Amount of grass, square centimeters per square meter.	Percentage of maximum year.	Amount of grass, square centimeters per square meter.	Percentage of maximum year.	Amount of grass, square centimeters per square meter.	Percentage of maximum year.	Outside range.	Pasture 2.	Pasture 5.
1915....	511	87.6	232	99.6	553	100.0	326	71.2	45.4	108.2	63.8
1916....	583	100.0	233	100.0	421	76.1	405	88.4	39.9	72.2	69.4
1917....	537	92.1	183	78.5	269	48.6	444	96.9	34.0	50.0	82.6
1918....	511	87.6	90	38.6	177	32.0	458	100.0	17.6	34.6	89.6
1919....	347	59.5	94	40.3	165	29.8	343	74.8	27.0	47.5	98.8

Pasture 2 showed steady depreciation from its maximum stand in 1915 to 32 per cent of this stand in 1918 and 29.8 per cent in 1919. As compared with the amount of forage on the protected areas the pasture was 27.8 per cent lower in 1916, 50 per cent in 1917, and 65.4 per cent in 1918. Granting that the figures for the protected-area curve are too high for 1917 and 1918, because of difficulty in determining the amount of dead grass, as explained on page 20, and that the 1919 curve point more nearly represents the depreciation due to the drought factor, there is still a difference of 52.4 per cent in favor of the protected areas as compared with pasture 2 range. The greater loss in pasture 2 is attributed primarily to the heavy grazing during the main growing season in 1916–17 and in 1918, and approximately full stocking the rest of the year, as shown in Table 8. The soil in pasture 2 is not as compact as that in the protected areas or in pasture 5, and consequently dried out more quickly. In addition, the area was slightly overgrazed in 1917, but this slight over-

grazing and difference in soil could hardly account for more than a small amount of the difference in depletion had the area not been grazed, or had grazing been greatly reduced during July, August, and September. The low point of the pasture 2 curve in 1918 and 1919 as compared with the curve for similar range protected from grazing would indicate that the lack of available moisture for the existing stand of vegetation was not a prime factor in depreciation had the area not been heavily grazed during the growing season. This view seems warranted from the further facts brought out in the study of changes in the outside range when given protection during the growing seasons of 1918 and 1919, and because pasture 2 itself showed marked improvement under light grazing during the growing seasons of 1913 to 1915, inclusive.

Table 9 and figure 7 show that the stand of good grass forage in pasture 5 continued to increase up to 1918, when it reached its maximum for the period, but dropped 25.2 per cent in 1919 and showed practically the same amount of forage per unit of area as the protected areas at that time. Although these results differ from those on other areas under study, they appear warranted when all facts are considered. Soil conditions are slightly more favorable in this pasture than for the average grama-grass type, and the area received a few more light showers and slightly greater total rainfall than the average for the type in 1916 and 1918. In addition, the poor condition of the pasture in 1915 made available much opportunity for improvement. These advantages, combined with reduction in grazing during the main growing season, especially the latter, are thought to account for the steady increase up to 1918. Plate II compares the results of heavy yearlong grazing with reduction of grazing during the growing season.

The drop in condition in 1919 is partly explained by the average overgrazing during 1918, but was probably due more to the fact that the density of the vegetation had reached a point where it was greater than the available moisture would support and, consequently many of the young plants died late in 1918 and early in 1919 before the rainy season began. The study shows that the stand of good forage grass in pasture 5 at all times during the period was less than on the range totally protected against grazing. It is apparent, therefore, that except for the effect of grazing the pasture would support the increase in vegetation shown. The drop from 1918 to 1919 is consistent with the depletion on the area under protection and indicated that both of these areas had deteriorated to about the maximum stand that available moisture of 1918 would support. The lack of improvement in 1919, which was a wet year, on these two areas indicated further that abundant moisture alone is not sufficient for improvement after drought; at least one good year following drought

is necessary for the grama grass to recuperate in strength sufficiently to set about any material increase in density on ranges that have been maintained as high as available moisture would support during drought.

OVERSTOCKING.

That depreciation of the range will result from overstocking under any system of use is obvious, and too much emphasis can not be given to necessity for care, first in adjusting grazing use so as to give the main forage plants as much chance to grow as possible. consistent with good management of the stock, and then to avoid putting more stock on any area than it will carry under the plan of use decided upon.

The occurrence on the outside range (Table 9 and fig. 7) illustrates what may happen to a grama-grass range where care is not exercised. The only system of use possible on this area up to 1918 was yearlong grazing. No real effort was made properly to limit the number of stock to what the range would carry, and as a consequence, the range was only 45 per cent of what it should have been in 1915. As a result of the continued overgrazing it had depreciated to 17 per cent of what it should have been in 1918, near the end of the drought. As a direct consequence losses of live stock were excessive and the calf crop was greatly reduced. Furthermore, many of the more valuable forage plants were replaced by less valuable or worthless ones.

The condition of pasture 5 of the Jornada Range Reserve in 1915 showed also the results of overgrazing. Grazing for the year ended June 30, 1916, was considered 25 per cent too heavy, and indications were that the area had been overstocked previous to June, 1915. As a consequence the range in this pasture in 1915 was 41 per cent poorer in density of stand than that of pasture 2 adjoining, where both seasonal and annual grazing were more nearly correct.

Depreciation in pasture 2 of the reserve during the period 1917 to 1919, as shown in figure 7, is greater than is warranted even in time of drought. This depreciation most probably could have been reduced by lighter stocking during the main growing season without materially lowering the average for the year. Since this was difficult to arrange because of shortage of forage elsewhere, the average for the year should have been lower, or at least provision should have been made for the necessary reduction in stocking during another drought.

Indications of overgrazing.—Without careful records of grazing and range conditions covering a long period of years it is difficult to decide exactly the maximum stocking which will probably be possible without range depreciation. The result is likely to be slight

understocking with some loss of forage, or overstocking and consequent injury to the range. Although it would be far better and cause less loss of forage in the long run to understock slightly each year, the tendency in the past has been toward overstocking. Until the proper rate of stocking has been determined, however, careful observation of range and stock should make possible the detection of deterioration in time to provide for recuperation in a few seasons.

Overgrazing on grama-grass range in the Southwest may be recognized to some extent in its first year by observations of the degree of cropping of the grass. Ordinarily grama grass should not be cropped closer in any year than will leave the lower joints of a few grass stalks on each tuft. This will provide a means of revegetation under favorable conditions the next year.

Black grama grass reproduces mainly by *stolons*. A number of the mature flower-stalks of each plant bend to the ground, sending forth a crown of leaves at each node or "joint" which takes root when it strikes the soil. Eventually as the little plants become established the connecting part dies and an independent plant is thus formed. If the grass is grazed so closely that no nodes are left there is no opportunity to revegetate by this method.

In loose soil overstocking results in the trampling and loosening of the surface soil so that the roots of the grasses are exposed and wind erosion begins. If the stock grazing an area fall off in condition faster than other causes warrant, overstocking is no doubt occurring.

Following the first year of overgrazing unpalatable annual grasses and weeds and short-lived perennial plants usually increase along with a reduction in number of leaves and height of the grass and in the number of flowering stalks and stolons. These secondary species increase with continued overgrazing and deterioration of the range until they are the only vegetation present. This is the case within a radius of one-half mile around some stock-watering places in the Southwest. The main plants indicating the first stages of deterioration in the grama-grass range of southern New Mexico are such *annuals* and *short-lived perennial* plants as tall eriogonum, sixweeeks grasses, spectacle-pod, whitestem, and yellow caltrops.

The best indicators of later stages of deterioration are *dropseed grasses*, *leatherweed*, *silvery nightshade*, and *yellowbush*, followed by *snakeweed*, and finally the mesquite-sandhill type if overgrazing and wind erosion is allowed to continue too long.

Where overgrazing has reached the stage where mesquite sandhills are being formed it will be difficult to restore the range. Effort should be made to detect the breaking down of the range much earlier, or as soon as the annuals and short-lived perennials begin to increase and the good grasses to decrease. Figures 1 and 2,

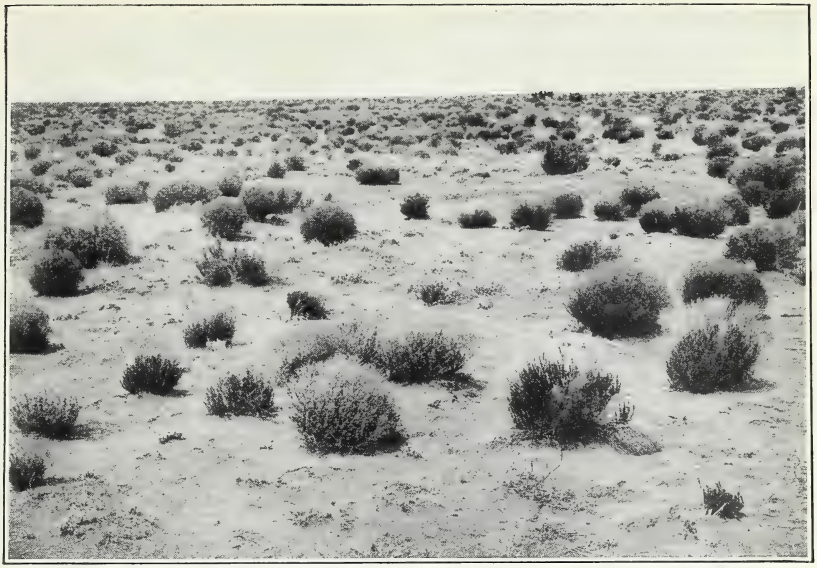


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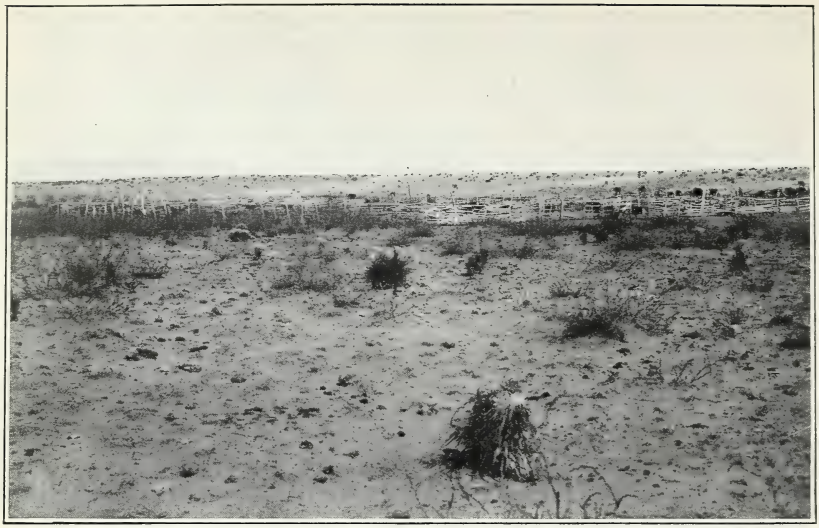
FIG. 1.—SNAKEWEED IS ONE OF THE MOST COMMON PLANTS FIRST TO "TAKE THE RANGE" WHEN OVERGRAZING OCCURS TO THE EXTENT THAT THE BETTER FORAGE GRASSES ARE KILLED OUT.

F-38571-A

FIG. 2.—THE ULTIMATE RESULT OF INJUDICIOUS GRAZING MAY BE A TRANSFORMATION OF A GRAMA-GRASS RANGE TO THE MESQUITE-SAND-HILL TYPE. BREAKING DOWN OF THE RANGE SHOULD BE DETECTED LONG BEFORE THIS STAGE AND STEPS TAKEN TO REPAIR IT.



F-35175-A

FIG. 1.—A BADLY CONGESTED WATERING PLACE ON THE OPEN RANGE WHERE THE DISTANCE BETWEEN WATERING PLACES IS 7 TO 12 MILES.

The result of great distances between waters is overgrazing and killing out of the best forage near water, with under-utilization beyond a distance of 4 miles on level range.

F-48713-A

FIG. 2.—WHEN WATERING PLACES ARE NOT MORE THAN 5 MILES APART ON LEVEL RANGE AND THERE IS NO OVERSTOCKING, STOCK SECURE EVEN UTILIZATION OF THE RANGE AND THE VEGETATION EXTENDS ALMOST UP TO THE WATER.

Contrast with fig. 1 where there is very little good forage within a mile of water.

Plate III, illustrate the successive stages of the effects of overgrazing.

FORAGE PRODUCTION CONCLUSIONS.

Conclusions from the forage-production data obtained thus far may have to be changed when data from observations through another drought period are available. These tentative conclusions point the way, however, toward certain essentials in determining the grazing capacity of the range and are a basis for adjusting grazing management and use preparatory to the next drought. The main points indicated by the study so far are:

(1) Grama-grass range similar to that on the Jornada Range Reserve begins to die out the second year of drought, and when a drought lasts three years the stand of forage on ungrazed range may be reduced as much as 40 per cent. The volume of forage produced per unit of area is further reduced by decreased height growth and foliage production during dry years. The vigor of the grass is affected to such an extent that at least one good year following drought is necessary before the range will begin to improve in density. In the case of tobosa-grass range there is less dying out of the grass, amounting to only 30 per cent in the third year of drought, but the volume of forage produced per unit of area is affected more directly by the amount of moisture received. The actual reduction in the amount of forage produced at the worst of the drought, taking into consideration both reduction in density and reduction in foliage production is about 50 per cent of the amount produced in good years on both grama-grass and tobosa-grass range.

(2) The depreciation of grama-grass range is greater as overgrazing increases and especially under too heavy grazing during the main growing months—July, August, and September. If grazing on it is reduced approximately one-half the year-long rate during July, August, and September, and if it is not too heavy the rest of the year, grazed range may be maintained in about the same condition as ungrazed and run-down range may improve to approximately the same condition. Apparently tobosa-grass range may be grazed heavily during the growing season, whether or not there is drought, without affecting it materially.

(3) Overgrazing a range results in a decrease in the best forage species on the range and their replacement by plant species of less forage value.

(4) In time of drought so great a reduction as 50 per cent of the volume of forage produced in more nearly average years may be expected and should be prepared for. Grazing should be reduced on grama-grass range during the main growing season, July, August,

and September, but grazing at that time does not seem to affect tobosa-grass range, so that the latter should be used for summer range and the former at other times. Should grama-grass range be overgrazed this fact may be detected by the various plant species that come in on the range and steps should be taken to reduce grazing and protect the range during the growing season.

GRAZING CAPACITY.

The effect of drought and time of grazing upon the grazing capacity of the range is of prime importance in working out a plan of management to secure maximum maintained cattle production on southwestern ranges. The summary given in the last few pages shows that there is a great reduction in amount of forage produced per unit of area due to drought and considerable variation due to difference in the time and extent to which the grama-grass range is grazed. The data show also that the reduction increases with each year of drought. Should the first few years following drought be favorable an increase in forage production toward the maximum will undoubtedly occur. To determine approximately what these changes mean in number of stock or percentage of stock, from year to year throughout a cycle including a drought and the good years following, is a problem that must be solved if similar conditions are to be prepared for in advance and the "downs" of cattle production on ranges of the Southwest be reduced or eliminated.

By grazing capacity is meant amount of grazing that may be secured per unit area. Usually this amount is expressed, however, in acreage per head of stock on any given range for the period the range is used. On most of the southern New Mexico ranges the stock are grazed yearlong. Grazing capacity is therefore expressed in terms of acres per head for the yearlong period, or, in other words, acreage required to furnish a year's grazing for one animal, although grazing may be lighter than average during part of the year.

True grazing capacity obviously is the acreage of a given range required to support one animal of a given class over a period of years without injury to the range. This ideal is difficult to attain on any range and is especially so on ranges of southern New Mexico, which are subject to the changes and variable factors briefly discussed in preceding pages. It is hoped, however, by careful records and adjustments over a period of years to approach the ideal closely enough to avoid unwarranted waste of forage through nonuse and certainly to avoid the serious overstocking common in the past. Improvement in grade of stock and comparatively higher prices for better stock in thrifty condition will aid in approaching the ideal by making it profitable to insure proper care of the stock through

sufficient range forage and supplemental feeding. Rapid advancement in this respect has already taken place in the past few years.

Along with the records of change in vegetation under protection against grazing and undergrazing over the period 1915 to 1919, inclusive, daily records have been kept of the animal days feed furnished by each of the pastures on the Jornada Range Reserve, and approximate figures by seasons for adjoining and nearby unfenced ranges have been obtained.

YEARLONG OR WINTER RANGE.

The main portion of the yearlong or winter range, consisting of the pure grama grass, part of the mixed grass, the snakeweed, and the mesquite-sandhill types on the Jornada Range Reserve occurs in pastures 2, 5, and 10. Carrying-capacity data for these pastures and for similar outside range grazed yearling (Tables 10, 11, 12, and 13) show the reduction in carrying capacity during drought and the effect of the time and degree of grazing.

In the tables condition of the range, in each case, with the exception of pasture 10, is compared with the protected areas for each year when such data were available, to eliminate approximately the factor of moisture and get at the influence of grazing alone in causing range depreciation.

TABLE 10.—*Grazing capacity of pasture 2, 1913 to 1919.*

[Area of pasture, 34,545 acres.]

Period, July 1 to June 30.	Average acres per head per year (365 days).	Estimated per cent of available forage utilized.	Estimated grazing capacity in acres, per head.	Condition of range in per cent of condition on protected area.
1913–14	26.6	100	26.6	.....
1914–15	47.0	57	26.6	.....
1915–16	33.1	80	26.5	108.0
1916–17	43.9	90	39.5	72.2
1917–18	42.6	[1] 125	53.2	50.0
1918–19	93.6	90	81.2	34.6
1919–20	.....	.....	.....	47.5

[1] 80,900 pounds of cottonseed-cake fed in this pasture during the spring of 1918, which increased utilization 25 per cent.

TABLE 11.—*Grazing capacity of pasture 5, 1915 to 1919.*

[Area of pasture, 2,815 acres.]

Period, July 1 to June 30.	Average acres per head per year (365 days).	Estimated per cent of available forage utilized.	Estimated grazing capacity in acres, per head.	Condition of range in per cent of condition on protected area.
1915–16	23.1	125	28.1	63.8
1916–17	36.0	100	36.0	69.5
1917–18	35.2	100	35.2	82.7
1918–19	22.3	125	27.9	89.6
1919–20	.....	.....	.....	98.8

TABLE 12.—*Grazing capacity of pasture 10, 1915 to 1919.*

[Area of pasture, 4,805 acres.]

Period, July 1 to June 30.	Average acres per head per year (365 days).	Estimated per cent of available forage utilized.	Estimated grazing capacity in acres, per head.	Condition of range in per cent of condition on protected area.
1915–16	32.5	85	27.6	.....
1916–17	43.2	90	39.0	.....
1917–18	20.1	[1] 183	36.8	.....
1918–19	33.5	100	[2] 33.5	.....

[1] 64,500 pounds of cottonseed cake were fed in this pasture during winter and spring of 1918, which increased utilization 83 per cent.
[2] Mostly short-age yearlings in the pasture.

TABLE 13.—*Estimated grazing capacity of outside range, 1914 to 1919.*

Period, July 1 to June 30.	Average acres per head per year (365 days).	Estimated per cent of available forage utilized.	Estimated grazing capacity in acres, per head.	Condition of range in per cent of condition on protected area.
1914–15	26.3	125	32.9	.....
1915–16	26.3	125	32.9	45.4
1916–17	32.8	125	41.0	40.0
1917–18	81.1	125	101.4	34.2
1918–19	98.5	100	98.5	17.6
1919–20	.....	.....	.....	27.1

A comparison of these tables shows that estimated carrying capacity of the four areas was approximately the same for the annual period ending June 30, 1916. Pastures 2 and 10, with an average of 27 acres per head per year, were probably at their maximum average carrying capacity in 1915–16, having had the opportunity to reach this condition through very light grazing during the growing period for several seasons previous. Pasture 5 and the outside range were slightly below their maximum on account of overstocking yearlong with no opportunity for recuperation during the growing season for several years previous.

Table 10 shows that the average grazing for each year in pasture 2 exceeded the estimated grazing capacity for the respective year only in 1918, and that the excess in 1918 was due mainly to the feeding of 80,900 pounds of cottonseed cake to stock in the pasture. It is probable that the average grazing for the year was slightly in excess of the amount of forage. This slight excess, however, does not account for the depreciation of pasture 2 from 108 per cent of the protected areas in 1915–16 to 34.6 per cent of the same protected areas in 1918–19. As pointed out in the last chapter this seemingly unwarranted depreciation was attributed primarily to the failure to reduce grazing during the growing season, July to October.

Table 11 shows that, although pasture 5 was grazed more heavily on an average each year than pasture 2, the range improved in production of the main forage grasses and increased slightly in carrying capacity each year after 1916–17. The pasture was considered overstocked only in 1915–16 and 1918–19, and stocked about right the other years. Although heavily stocked the pasture held up well, probably as a result of reduction in grazing during the main growing season. Comparison of pastures 2 and 5 indicates that it was not overgrazing but heavy grazing during the growing season that was responsible for deterioration of pasture 2, and that the pasture would have sustained as an average for each year the number of stock actually grazed if grazing during the growing season had been more judicious.

Pasture 10 (Table 12) agrees rather closely with pasture 5 in estimated grazing capacity for the period. The actual difference was perhaps a little greater than shown in the tables in favor of pasture 5, as the drought was more severe in pasture 10 and in 1918 mainly short-age yearlings were grazed in the pasture, this class of animals requiring less range per head than cows. As in pasture 5, the prime factor in keeping this pasture up in carrying capacity was reduction in grazing during the main growing season.

Table 13 shows that the average grazing on the outside range exceeded the estimated grazing capacity each year with the exception of 1918–19, and that, except in 1918–19, the grazing capacity as well as the condition of the outside range in comparison with the protected areas continued to decline up to 1919–20. The overgrazing during the whole year no doubt contributed a great deal to the decline in productivity of the range, but the overgrazing during the growing season, as brought out in the last chapter, was mainly responsible for the heavy reduction in the condition of the forage and grazing capacity. The slight increase in the grazing capacity in 1918–19 and the improvement in condition of the range in 1919–20 is largely due to the reduction in number of stock to more nearly what it should be, and light grazing during the main growing seasons of 1918 and 1919.

The information obtained on yearlong winter range to date indicates that, while decreased grazing capacity will result during drought, the reduction may not be greater than the amount due to drought alone if the range is correctly managed. The main consideration is to handle the range so that grazing will be light over as much of this class of range as possible during the main growing season—July to October. Without this provision the range will deteriorate faster during time of drought, varying with the time and intensity of grazing.

The estimated grazing-capacity figures in Tables 10, 11, and 12 are computed from careful observations and estimates in each pasture by years on the basis of rather full use of available forage each year without knowledge or special consideration of what conditions would be the succeeding year. This method was followed because there was little chance for change except to increase supplemental feeding while the drought was on, and it was desired to have a close estimate of total grazing capacity by individual years as a basis for the progressive adjustments for a similar period in the future. While the stock on the reserve was carried over the drought with a maximum annual loss of 3.5 per cent as compared with a maximum annual loss of about 35 per cent for the surrounding country, without more feeding than will probably be profitable during another similar period, and without injury to the range other than caused by drought alone, except in pasture 2, the experience during 1916 to 1919 warrants a greater margin of safety even than would be provided by the estimated grazing-capacity figures given. This conclusion seems warranted considering the great worry and strenuous effort to prevent losses, the rather large reduction in calf crop, and the lack of satisfactory growth of young animals, especially during 1917 and 1918. Had the drought continued another six months the expense of feeding would probably have been almost prohibitive.

RATE OF STOCKING TO PROVIDE FOR DROUGHT.

Using as a basis the amount of forage produced on the protected areas during the drought, the results in maintaining the condition of the forage comparable to the protected areas in pastures 5 and 10 under the system of grazing used there, and the difficulties encountered in carrying the stock through the drought on the reserve, it is possible to decide upon a guide for the proper rate of stocking during drought in future.

Considering 1915–16 as about the maximum average condition which can be expected for the yearlong or winter range of the reserve, or for similar range, the maximum stocking should not exceed the estimated average required per head in pastures 2 and 10 in 1915–16, or an average of 27 acres per cow for yearlong grazing, and should only be this heavy when it can be controlled so as to reduce grazing 30 to 50 per cent from average during the growing season—July to September, inclusive. The forage produced in 1916–17, the first years of drought, as shown by the protected areas, would not necessitate much reduction in grazing that year; but with the prospects of further dry years to follow, it is considered best to reduce grazing about 15 per cent the first year of drought and save the surplus grass for succeeding years. A summary of the estimated

carrying capacity of pastures 5 and 10 in 1917–18, the second year of drought, as given in Tables 11 and 12 shows an estimated reduction of about 35 per cent from maximum in an average year. From the difficulties encountered in 1917–18, however, it is believed that

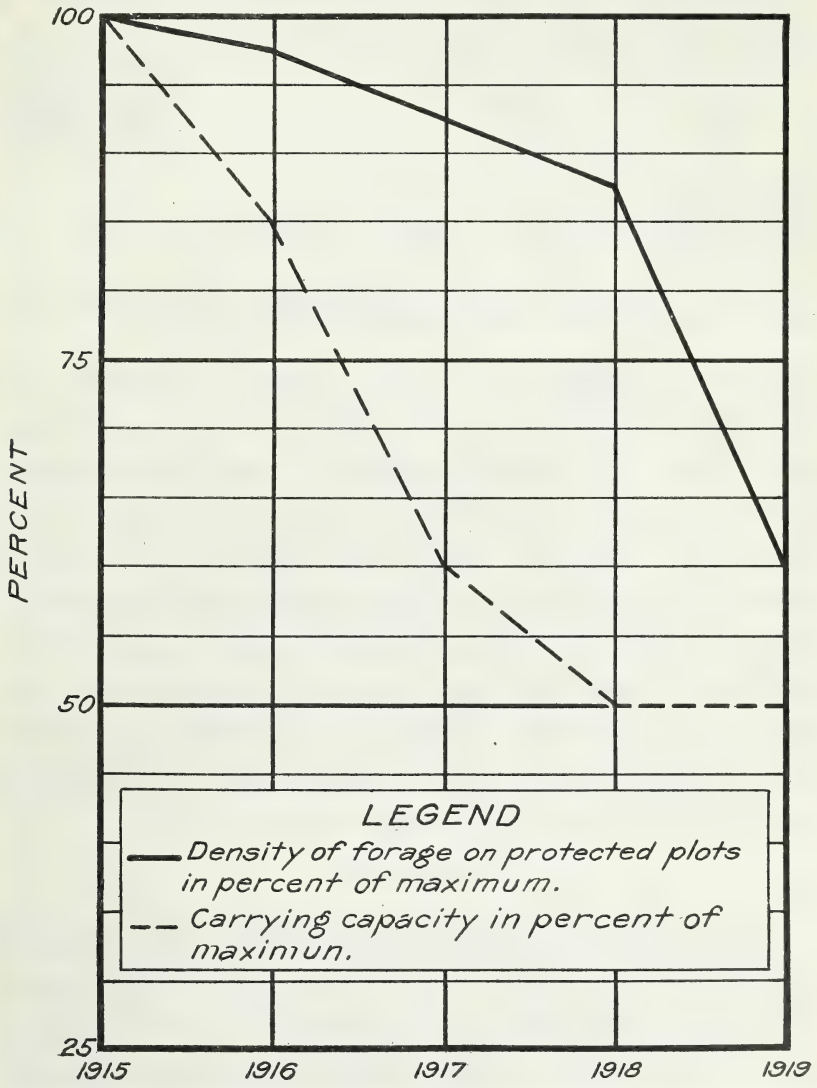


FIG. 8.—Estimated carrying capacity of grama-grass range in time of drought.

during the second year of drought there should be a reduction in number of stock grazed of at least 40 per cent from maximum estimated grazing capacity and a further reduction of 10 per cent in the third year.

The basis decided upon as a guide on the reserve in the future during drought, therefore, is shown in Table 14.

TABLE 14.—*Rate of stocking recommended for grama-grass range, Jornada Range Reserve, during period of drought as compared with maximum grazing capacity.*

Period.	Rate of stocking in acres per head for 365 days' grazing.	Rate of stocking in per cent of maximum grazing capacity.
Year before drought	27.0	100.0
First year of drought	32.2	85.0
Second year of drought	45.7	60.0
Third year of drought	54.0	50.0
Fourth year of drought[1]	54.0	50.0

[1] This estimate is for the drought of 1916–1919. Should drought continue throughout the fourth year or longer, a greater reduction would be necessary depending upon existing conditions.

Intensity of grazing on this basis is shown in comparison with the changes in condition of representative grama-grass range protected against grazing prior to and throughout the drought which ended in 1919. In connection with figure 5, page 21, the probability of this curve (density of vegetation) being too high for 1917 and 1918 was pointed out. The points for 1915 and 1919, however, can be relied upon. Figure 8 shows a more rapid and greater total reduction in proposed intensity of grazing than in depreciation of range due to drought alone. The difference should make possible the maintenance of the range somewhere near the condition of protected areas. Just what further reduction in stock would be necessary in case of prolonged drought is problematical. It is hoped, however, that a maximum reduction of about 50 per cent and supplemental feeding will take care of the stock during droughts which may occur in the future on the range reserve.

SUMMER RANGE.

Tables 15 and 16 show grazing capacity data for pastures 13 and 1, respectively. Pasture 13 is the most nearly representative of the range suitable primarily for summer grazing, but was not so badly affected by drought, receiving more rainfall than any other part of the reserve. Pasture 1 was representative as to drought, although there is a large area of mesquite-sandhill and grama-grass types in addition to the summer range.

TABLE 15.—*Rate of stocking and estimated carrying capacity, Pasture 13, 1915 to 1919.*

[Area of pasture 17,001 acres.]

Period, July 1 to June 30.	Average acres per head for 365 days' grazing.	Estimated per cent of forage utilized.	Estimated grazing capacity acres per head for 365 days.
1915–16	42.3	100	42.3
1916–17	64.5	80	51.6
1917–18	65.1	90	58.6
1918–19	114.4	50	57.2

TABLE 16.—*Rate of stocking and estimated grazing capacity of Pasture 1, 1915 to 1919.*

[Area 74,714 acres.]

Period, July 1 to June 30.	Average acres per head for 365 days' grazing.	Estimated per cent of forage utilized.	Estimated grazing capacity acres per head for 365 days.
1915–16	48.6	100	48.6
1916–17	48.2	100	48.2
1917–18	85.3	100	85.3
1918–19	71.3	80	57.0

These tables show that the carrying capacity of the summer range has varied from 42.3 acres per head in good years to 85.3 acres per head in time of drought, a reduction of 50 per cent. Extent of grazing during the growing season does not affect this type materially, although the amount of forage produced and consequently grazing capacity are greatly influenced by precipitation. If the 1916–18 dry period is a fair measure of the possible severity of drought, and it probably is, the number of stock dependent on such range for summer grazing should be reduced approximately 50 per cent in the third dry year, with some reductions necessary the first and second years. This corresponds to the reductions recommended for the grama-grass range. It is believed that the reduction in stock during drought, as proposed in Table 14, will apply to both the grama-grass and tobosa-grass range and therefore to the Jornada Range Reserve as a unit or to other range units under similar management in southern New Mexico.

ADJUSTMENTS NECESSARY IN CATTLE MANAGEMENT.

The great reduction in the volume of forage produced during drought and its effect on the grazing capacity or percentage of stock grazed, and the impracticability of extensive feeding to meet the de-

mands of such a situation, make it seem obvious that the character and extent of livestock production in the section where these conditions prevail should be carefully adjusted to the supply of range forage as the primary source of feed. This is at least so until such time as agricultural development and economic conditions change in a way to supply other feeds in amount and at a price compared with the value of stock which make extensive feeding profitable.

The number of stock grazed must either be confined at all times to the number that the range will carry over periods of drought, or provision be made to reduce the number of stock when drought begins and increase them again with the improvement of range following drought. To limit the number of stock in good years to the number that can be carried over in drought would entail the loss of a great amount of forage, amounting in good years to as much as 50 per cent or more of the carrying capacity in normal years. The situation calls for an adjustment in the business that will permit obtaining the maximum use of the forage produced in good years, but at the same time will permit orderly reduction in the number of stock in time of drought without loss.

Using as a basis the data on the volume of range forage which may reasonably be expected annually over a period of years including a drought and the effect of this variation upon grazing capacity or percentage of stock grazed each year, as arrived at in the preceding chapters, it remains to decide upon the class of stock and their numbers and management annually and for a period of years including a drought.

SOUTHERN NEW MEXICO A CATTLE-BREEDING SECTION.

All stockmen may not agree that the ranges of southern New Mexico are essentially a cattle-breeding ground. The facts, however, appear to warrant this statement. One alternative would be to obtain steers at an early age and grow them to 2, 3, or 4 years of age for shipment to northern and middle western pastures and feed lots to be finished for beef. The difficulty of this practice is to obtain the steers. In times past large numbers were obtained from Mexico. As a future practice this has but doubtful possibilities, since it will be some time before Mexico has any certain surplus of steers for export.

The best permanent interests of the section will be served by developing the industry to produce calves and steers and surplus cows, at least as long as present conditions prevail. In working out livestock production on this basis obviously the foundation is the breeding herd, with variation in the number and ages of steers to conform to variation in supply of range forage and market conditions.

BREEDING HERD SHOULD BE LIMITED TO GRAZING CAPACITY OF THE RANGE DURING DROUGHT.

The tendency has been to increase the breeding herd during good years to the limit of range capacity and in many instances beyond this limit. When drought came on, anything for which there was a market was sold, and thus years of effort in improving the herd were lost, at least in part, while losses from starvation were excessive. The increasing cost of producing the individual animal and the growing importance of improving the average grade of stock, to meet the demand from the feed lots, both argue against continuation of this old practice. The alternative is to limit the breeding stock to the number that can be taken care of during periods of drought.

BREEDING HERD ON THE JORNADA RANGE RESERVE.

In attacking this problem on the Jornada Range Reserve the original plan was to keep two-thirds of the normal grazing capacity of the entire range for breeding cows, young heifers to replace culls from the breeding herd, bulls, saddle horses, and a few brood mares. Table 17 shows the number of these classes of stock carried each year through the period 1915 to 1919 including a drought, the percentage of the range used for each class of stock, and the amount of forage crop produced each year in percentage of the 1915–16 crop, which is considered about maximum for the reserve.

TABLE 17.—*Number by classes of stock making up permanent herd on Jornada Range Reserve, each class in percentage of total grazing capacity of the reserve in 1915–16, and estimated forage production in terms of 1915–16 crop.*

Year.	Cows of calving age.		Bulls.		Heifers 1 year old and up not yet placed in breeding herd.		Horses.		Total in percentage of total grazing capacity, 1915–16.	Estimated forage crop production, percentage of 1915–16, production.[1]
	Number.	Percentage of total carrying capacity, 1915–16.	Number.	Percentage of total carrying capacity, 1915–16.	Number.	Percentage of total carrying capacity, 1915–16.	Number.	Percentage of total carrying capacity, 1915–16.		
1915–16	1,950	41.75	80	1.71	695	14.87	120	2.56	60.89	100
1916–17	2,022	43.27	80	1.71	751	16.07	140	3.00	64.05	81
1917–18	1,986	42.49	80	1.71	892	19.08	180	3.85	67.13	54
1918–19[2]									49.42	64

[1] The 1915–16 range is considered near maximum condition and therefore is used as the basis of comparison. The amount of forage produced in other years was arrived at by careful estimates of the amount produced on the reserve as a whole checked by quadrat measurements and number of stock the range was actually able to support.

[2] During the grazing year ending June 30, 1919, the various herds were disorganized by removal to other range for part of the year. However, an average of 2,310 head of stock were grazed during the year.

The last two columns of Table 17 show, first, that only in 1917–18 did the breeding herd, including other permanent stock, exceed two-

thirds of the grazing capacity in 1915–16, which was near maximum; and second, that only in the same year, 1917–18, did the estimated range forage production fall materially below approximately two-thirds of production in 1915–16, and even then the excess was less than 1 per cent. The original plan, however, was to reduce other stock so as to keep total grazing well within forage production. Table 18 shows what was actually done.

TABLE 18.—*Permanent stock, steers, and total, compared with forage production by years.*

Year.	Permanent stock in percentage of total grazing capacity, 1915–16.	Steers.		Total in percentage of grazing capacity, 1915–16.	Forage production in percentage of 1915–16.
		Number.	Percentage of grazing capacity, 1915–16.		
1915–16	60.89	1,542	32.99	93.88	100
1916–17	64.05	831	17.78	81.83	81
1917–18	67.13	477	10.20	77.33	54
1918–19	49.42	None.		49.42	64

The last two columns of Table 18 show that the total number of stock was slightly in excess of the forage production in 1916–17, the first dry year, and 43.2 per cent in excess of estimated forage production in 1917–18.

In disposing of steers the original plan was followed, but not soon enough. In the fall of 1915 it was evident that there would be considerable forage not needed by the permanent herd. Additional yearling steers were purchased and held over and sold in the spring of 1916 at a fair profit. Although in 1916 the prospect for surplus forage was not so good, it still appeared that there would be more range than needed for the permanent herd. The natural increase of steers under 2 years old, about 750 head, was held over, but only a few additional steers were purchased. Most of these steers were sold in the spring of 1917. After the growing season of 1917 it was evident that there would be a shortage of range forage for the permanent herd, and consequently all steers down to calves 4 months old were sold. Removing the steers late in the fall, however, and holding over a few surplus cows amounted to an average of 477 head of this surplus stock during the grazing year, July 1, 1917, to June 30, 1918.

Had the steers been sold in the spring of 1917 or earlier instead of holding them over until fall, much worry would have been avoided and the cost of supplemental feeding and losses would probably have been reduced. As it was, supplemental feeding, as given in Table 19, was considered advisable.

TABLE 19.—*Records of supplemental feeding to cows and heifers in breeding herd.*

Year.	Number stock fed.	Per cent of breeding cows.	Character and amount of feed.	Total cost of feed and feeding.	Cost per head.	Cost per head for entire herd.
1915–16	445	2.3	32,600 pounds cottonseed cake	$652.00	$1.47	$0.33
1916–17	420	2.0	39,470 pounds cottonseed cake	1,051,69	2.50	.52
1917–18	[1] 1,769	89.0	171,016 pounds cottonseed cake. Pasturage, 353 tons soapweed [2].	8,747.36	4.95	4.40
1918–19 [3]						

[1] Includes only cows and heifers in breeding herd; bulls, calves, and young heifers not included.
[2] Pasturage for 215 cows and young calves for about three months, November, December, and January, $2,304.72.
[3] No feeding.

Even in good years the feeding of cottonseed cake or other concentrated feeds in small amount to the breeding stock to keep losses at a minimum and the stock in condition to produce a good calf crop is considered good business. The feeding in 1915–16 and in 1916–17 was for this purpose rather than because of lack of range forage. Feeding in 1917–18, however, was largely a necessity to get the stock through in any condition. Much heavier feeding would have been necessary to have maintained calf crop and losses at approximately what they were in other years. The losses were extremely low compared with either the average for this section over a period of years or the average for the drought, but were 3.5 per cent as compared with 1.7 per cent average for 1915–16–17 on the reserve. The calf crop in 1919 was 43 per cent as compared with 64.7 per cent average for 1915 to 1917 on the reserve. Further, the overstocked condition resulted in marked injury to pasture 2, the main grama-grass pasture of the reserve, and the possibility of heavier loss was too great. Had the drought continued another year with both stock and range in poor condition and surplus forage all used the situation would have been serious.

The $4.40 per head cost of supplemental feeding in 1917–18 for breeding stock is not considered a serious matter, provided losses are kept down to about what they were for the reserve in 1915 to 1917 and the calf crop up to about what it was for that period. To have accomplished this in 1917–18, however, a material reduction in stock would have been necessary after the critical period arrived. The difficulty of selling surplus stock in poor condition at that time without a heavy sacrifice emphasizes the necessity for reducing the herd in advance.

The fact that forage production at the worst of the drought was estimated at only 54 per cent of what it was in 1915–16 over the whole reserve and only 60 per cent on the areas protected from grazing, and the probable difficulty of getting rid of all but breeding stock at the right time, lead to the conclusion that instead of using

two-thirds of the maximum grazing capacity as the basis of the permanent breeding herd 50 per cent should be used in future. This percentage, about 2,000 head,[12] will be made up almost entirely of cows of breeding age, bulls, saddle and work stock, and perhaps about 3 per cent of heifers selected to replace loss and such cows as must be removed from the herd on account of injury or other causes.

With this number of stock and percentage of total stock for the breeding herd combined with the data contained in figure 8, figure 9 has been prepared to show the breeding herd, the stock other than breeding stock, and the total stock in relation to maximum condition of the grama-grass range as shown by protected areas for the respective years.

Figure 9 applies to the reserve for the period 1915 to 1919, inclusive. This covers conditions in the more nearly average year of 1915, which was about five years after the drought of 1908–1910 had broken and through the drought of 1916–1918. From data and observations as to conditions from 1910 to 1915 and from the precipitation records shown in figures 2 and 3 there is probability at least that the curve for total grazing capacity for 1920 to 1923, inclusive, will be approximately the reverse of the grazing-capacity curve shown in figure 9 for 1915 to 1918, inclusive. If the climate continues in cycles as in the past there will probably be another drought about 1924. The future management of the Jornada Range Reserve will be based upon these two assumptions. The breeding herd came through the drought of 1916–1918 with nearly enough good young breeding cows for the permanent breeding herd recommended. The question now is to decide what class of stock should be kept to use the gradually increasing surplus range forage up to 1924, or up to the next drought, and at what age to dispose of the excess stock produced.

SURPLUS STOCK SHOULD VARY WITH RANGE FORAGE PRODUCTION AND WITH THE MARKET.

As shown in figures 8 and 9, after the permanent breeding herd recommended is taken care of there will be surplus forage varying from nothing at the worst of the expected drought to 50 per cent of the total for a given range unit about 3 to 5 years after a drought is broken, and possibly more in a period of exceptionally good years. This, of course, assumes that the range is to be properly managed so that it will recover.

[12] Originally the pasture in the San Andres Mountains was included as part of the area to be used by breeding and other permanent stock of the reserve in time of drought, the surplus forage being used by horses and extra stock in good years. Because of the extremely rough topography and rocky surface, poor success was obtained in trying to use this area by stock accustomed to the level ground where there were no rocks. Consequently the plan for the future is to use this area for horses and steers or other stock that are placed in the mountains as yearlings and left there long enough to become accustomed to the rough country, and not as part of the breeding area proper.

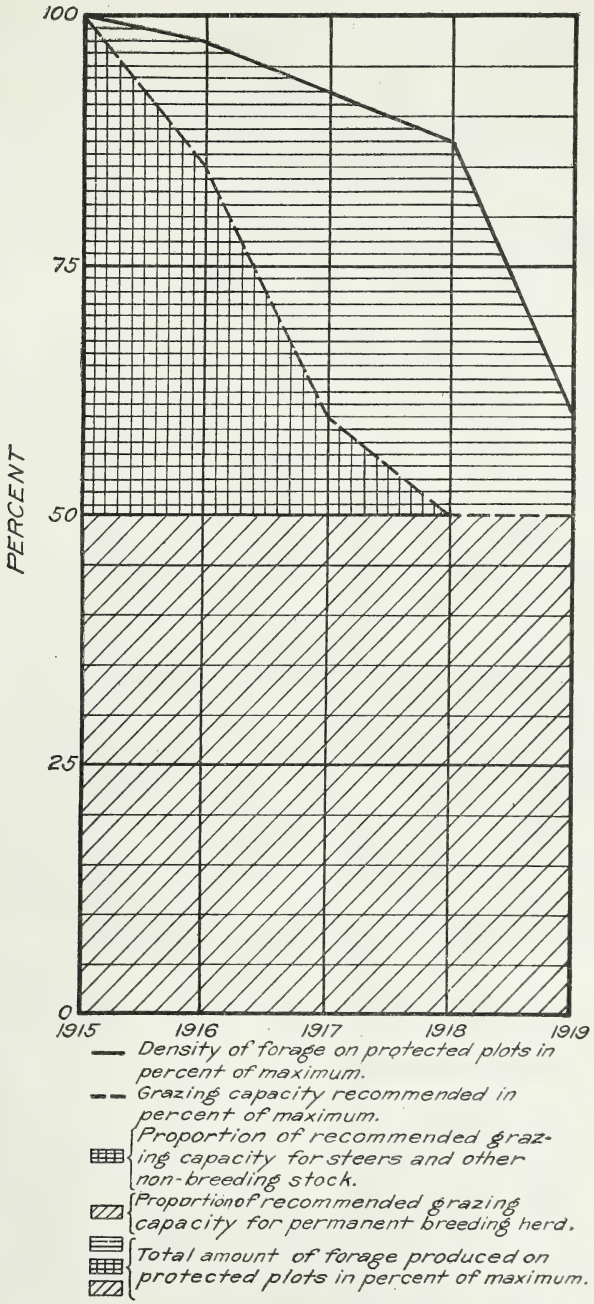


FIG. 9.—Amount of breeding stock and nonbreeding stock recommended in proportion to forage production on protected plots over a period of years.

There are several possibilities for profitable use of this surplus forage. First, provision must be made for reserving enough heifers from the natural increase of the breeding herd to provide for improving the breeding herd by culling and replacement. The breeding herd recommended provides about 3 per cent of heifers to replace loss and a small additional percentage of injured and unthrifty cows, but does not provide for heavy culling to improve the grade of the herd or to get rid of old cows. Stockmen will probably differ as to the best policy to pursue. The Jornada breeding herd was carefully culled over in 1919, and it is not probable that heavy culling will again be undertaken for several years. Before another drought, however, or about 1924 if no drought is evident at that time, about 50 per cent of the present breeding herd should be replaced by heifers selected from the natural increase. This replacement will serve the double purpose of improving the grade and providing a herd made up of young cows best able to withstand the hardships of drought. To get the best results the heifers for replacement should be selected from calf crops in years when forage conditions are favorable to development of young stock, probably from those before 1922, so that they will be at least two years old when put into the breeding herd.

Whether additional heifers will be held over will depend upon the demand and market for young breeding stock as compared with demand and market price for steers. During the next few years there will probably be demand for heifers to build up herds greatly reduced during the drought. There is also the possibility of holding over some heifers in good years in addition to those necessary for replacement in the permanent breeding herd, to increase this herd temporarily and thus secure some additional calves in good years. Further total increase in stock should then be held down by selling young stock as calves. Increase in the breeding herd is dangerous, however, unless such increase will be disposed of before another drought. The actual time when the next dry spell may start, of course, can not definitely be foretold.

Prior to 1918 on the Jornada Range Reserve most of the heifers were held over as part of the breeding herd, because of the heavy culling of this herd to improve both grade and age. This was considered warranted in view of the rapid improvement desired, but even then losses would probably have been lighter and cost of feeding not so heavy in 1918 if plans had been made beforehand and part of the heifers disposed of each year during the drought.

There is usually demand for steers 1 year old or over at any time of the year. In the past the policy at the Jornada Reserve has been to use for steers most of the forage not needed by the breeding herd. This policy, instead of holding over heifers for sale, has been with-

out question in the past, however, because of the demand for heifers to replace culls in the breeding herd to improve both grade and age. These steers, while not in condition to go as feeders, have supplied a demand each year in the past to go to northern and middle western pastures and have always been handled at a profit. Producing feeder steers, as discussed later under feeding, may prove in the future to be good business, and if so the holding over of more steers rather than heifers may be advisable.

There is usually a good demand for well-bred calves at weaning time in the fall, and the sale of an entire calf crop is a possibility if the range is fully stocked and the market is not right for the surplus stock already being held.

The number of surplus stock, therefore, should be adjusted carefully to the available range forage not needed for the breeding herd, and the class of stock held to use this surplus forage will be governed by demand and market price for the different classes. Over a period of years the demand and price will probably be in favor of steers.

As in the past, the temptation will be to overstock before the range has fully recovered after drought and not to reduce the stock prior to the drought. This overstocking comes by holding all heifers to increase the breeding herd after drought and holding steers at least to 1 year old. In the Southwest this policy has been expensive in the past and will be equally or more expensive in future unless due care is taken to keep the total stock each year well within the probable grazing capacity of the range unit involved. Until data over a longer period are available, therefore, it is believed that the variation in forage crop and in numbers of stock by classes as presented in figure 9 should be followed as a guide in stocking southern New Mexico and similar range.

RANGE MANAGEMENT TO OBTAIN MAXIMUM FORAGE PRODUCTION AND PROPER USE.

Along with the study of the effects of time and degree of grazing upon the stand of forage on the range on the Jornada Range Reserve the plan has been to work out a system of grazing management and handling stock that will meet the growth requirements of the forage as determined, and at the same time meet the practical demands of the stock. To be both sound and practical such a plan must secure maximum utilization of the forage consistent with its growth requirements and have an adequate supply of range forage available for the stock at all times of the year. Management of grazing to have a range available during April, May, June, and the early part of July especially, is important in the Southwest, where these months are

usually dry, and stock, especially breeding cows, are in the most critical condition.

SEASONAL USE OF RANGE.

Where grama-grass or yearlong range and tobosa-grass or summer range occur together, as they do on the Jornada Range Reserve, management of the range is a comparatively simple matter.

The chief requirement of grama-grass range, to obtain revegetatation and maintain it at its highest productivity, is protection or material reduction of grazing during the main growing season, July to September, inclusive. On the other hand, tobosa-grass or summer type of range, because of its growth habits and the character of the soil it occupies, does not suffer materially if grazed during the time it makes its main growth and must be grazed at this time if maximum utilization is to be secured. Division of these two classes of range, using the tobosa-grass and similar types during summer and fall, and holding the grama grass and similar types for use during the winter and spring, will serve the several-fold purpose of securing the full use of each, giving the grama-grass range the protection it requires during the growing season, and insuring a supply of winter and spring range for the stock.

Figure 1 shows how the various types of range have been divided into the two classes on the Jornada range reserve. Pastures 2, 3, 5, 10, and 12 are chiefly valuable for winter or yearlong range. Pastures 7, 8, 9, and 13 are best adapted to summer grazing. Pasture 1 contains both winter and summer range, but cattle are confined to the latter as much as possible by salting and closing waters on the former and later in the year opening these waters and salting on winter range. It was not always possible to put the fences directly upon the boundary between the two classes of range, especially where the types occurred more or less intermixed, without excessive fencing and water development, but the aim was to divide the range as nearly as practicable in this manner.

The plan has been to use pasture 13 as summer and fall range for a herd of 500 head and pasture 10 as winter range for this same herd each year. The more needy cows in pasture 10 during each spring were then separated and placed in pasture 7, a small reserve pasture. The larger breeding herd has been grazed in pasture 1 yearlong, with effort to confine the stock to the proper range at the proper season, except that all needy cows were separated and grazed in pasture 2, or one of the various smaller pastures where there was reserve feed, when their condition required it. Using pasture 1 as yearlong range with such control of stock as was possible by salting and riding has not been as satisfactory, however, as has been

division of winter and summer range by fencing for the 500-head herd. Future plans provide for the division of this pasture into summer and winter range. The benefits to the stock of this system of dividing the range and grazing it have been to carry them through the spring in much better condition and with less loss than on uncontrolled range, and it has had a desirable influence on the calf crop.

Where a range is not under control and is used yearlong, stock naturally graze the range more closely within the first mile or two of water first. Then later on, during winter and spring when the stock was poorest, they have to travel farthest from feed to water, this condition has often contributed to the heavy losses from starvation in the Southwest, especially where the distance between watering places is over 5 miles. This was largely overcome on the Jornada reserve by having a supply of fresh forage available near water for use by stock during the critical part of the year. Handling the cattle so that the more needy cows were placed on the winter range first gave them the further advantage of not having to compete with stronger stock. The latter were then left on the summer range until later to utilize completely any forage that still remained. The small winter-range pastures were held in reserve for use later in the spring by the most needy cows, especially cows to calve. Confining the breeding herd to less range during the main breeding season facilitates distribution of bulls among the cows, which is an important factor in increasing the calf crop. As is later pointed out, this has had material influence in securing larger calf crops in the special herd on the Jornada Range Reserve.

The principle is equally applicable on ranges where there is less pure summer range in proportion to the amount of winter or yearlong range available. Should a unit have a considerable amount of purely summer range but not enough to carry all the stock during the season, grazing may be planned so that such range may be fully used during the summer season and thereby reduce grazing on the winter range sufficiently to allow the 30 to 50 per cent decrease in stocking during the growing season for part of the winter or yearlong range each year. Following complete use of the summer range the stock should all be shifted to the yearlong range, with a sufficient amount held in reserve. for use by needy stock during winter and spring.

On a range unit that is all pure grama-grass or similar winter or yearlong range, the desired purpose may be obtained by use of the deferred and rotation system of grazing. Under this system the range is divided into three or more parts and grazing reduced at least 30 to 50 per cent of the yearlong rate during the growing season on one or more parts for two years in succession, or until the area

has had ample opportunity to recover to its proper stand of forage. As soon as one portion has been built up the same treatment should be given another part of the range and the process rotated so that the entire range will receive the benefits of the treatment every few years. Since part of the range is being more heavily grazed than the yearlong rate during the growing season, however, care should be exercised to see that this part is not injured before it receives an opportunity to be protected during the growing season.

DISTRIBUTION OF STOCK ON THE RANGE.

Full and even utilization of the forage, more especially on the larger subdivisions or units of range, is an important factor if best results are to be expected from a system of range management. On the Jornada Range Reserve, besides proper number and distribution of watering places, it has been found that other measures are very often necessary to secure the best results. When cattle are shifted from one part of a range to another there is a natural tendency for them to drift back toward their former range. Cattle are often slow to drift from the vicinity of water where grazing is quite close to another part of the pasture or range where there is more feed. Fencing in such instances may not be economical, but proper salting and range riding have been found of material benefit.

Distribution of water for stock.—Proper number and distribution of watering places are essential to avoid overstocking around water and secure full utilization of an entire range. It was pointed out[13] that permanent watering places on the plains and mesa range of the Southwest should not be more than 5 miles apart wherever the carrying capacity of the range and the cost of water development will warrant. As the distance increases beyond 5 miles there will be rapid increase in local overgrazing near the water and in uneven utilization beyond 2½ miles from water, with poorer condition and heavier losses among stock. Plate IV, figures 1 and 2, shows the effects of too great distances between waterings on the range and of proper distances.

It was also pointed out[13] that one permanent watering place to each 500 head of cattle is justified, and that where the conditions are favorable tanks should be constructed to catch flood waters to supplement the permanent watering places. Such tanks are of necessity limited to areas of suitable drainage, no tanks being possible on flat areas or those with extremely sandy soil. The southwest portion of the plains area of the Jornada reserve is well suited to tanking, and 14 surface tanks have been constructed to supplement the five perma-

[13] Department of Agriculture Bulletin 588.

nent waters on this part of the reserve. These tanks aid materially in securing the use of more green feed and in making it possible to relieve the range near the permanent waters a portion of each year.

Riding and salting.—The economical limits of water distribution at best will be such that there may be considerable overstocking and consequent range depreciation around water. This can be materially reduced by handling the stock to get better distribution than will naturally result when cattle are allowed to follow their own inclinations.

The practice found most effective on the Jornada Range Reserve in getting better distribution of the stock when first moved to fresh range has been to divide the herd into small bunches and place each bunch at a different water. If all were turned loose at a single water they would be slow in working out to the other waters, and overgrazing of a portion of the range would result.

Salting is one of the most effective means of attracting stock to a range, and, if sufficiently salted, stock will be less likely to drift away. Stock should have all the salt they wish at all times and care should be exercised to see that the supply never becomes exhausted.

Salting only at or near those watering places on the range where it is desired that stock should go, and refraining from salting at or adjacent to water around which the forage is already fully grazed or where there is overgrazing, will aid materially in proper distribution of stock. Salting on areas away from water that for some reason or other cattle might not be using has been found effective in getting better use of such areas.

There are times, however, when locating cattle in small bunches at the various waters and even proper salting will not prevent excessive numbers of stock around a single water. This is often the case around home waters where stock are frequently worked or around waters where a large number of stock have become located. In such cases it may be necessary occasionally to close the water entirely until the stock have become accustomed to go elsewhere to drink. Riding after the cattle and keeping them turned back toward their proper range will also help in reducing the stocking on run-down range, and riding to see that no cattle suffer from lack of water is essential where a permanent water is temporarily closed up.

IMPROVEMENTS NECESSARY TO MEET INCREASE IN COST OF CATTLE PRODUCTION.

Stockmen of southern New Mexico and of other similar sections realize that increasing value of range and costs of feed, labor, and general supplies call for readjustment of production methods, especially for greater assurance against heavy losses. Any change, how-

ever, must bring increased benefits commensurate with or greater than the extra costs incident to the change. Such benefits may be in the form of greater stability with less hazard, which will improve the credit of the industry both as to obtaining of loans and rate of interest, or in the form of increased net returns on the total investment over a period of years. The two will usually go together.

The existing difficulty in obtaining long-time loans at low rate of interest on breeding stock is due in part to the uncertainty of drought and of heavy losses accompanying it. This makes difficult the holding of stock until market conditions are right for the purchase of equipment and feed for proper care of the stock. Greater stability in the business will lead to the establishment of range live stock, and especially breeding stock, as better credit for securing of longer-time loans at a lower rate of interest.

The most direct and greatest benefits, however, must come from improving the grade of stock, increasing the average percentage of calves, reducing the loss in all classes of stock, and increasing the growth of young stock. Determining the possibilities of improvement along these lines has been an important feature of the investigations at the Jornada Range Reserve since 1915. A report of progress was published in 1917.[15] Data are now available through a period of drought.

IMPROVEMENT IN GRADE OF STOCK.

The plan of investigation and demonstration in improving the grade of stock provided for the selection and segregation of 500 of the best bred cows with Hereford characteristics, the improvement of the remainder of the herd by selling off-colored and poor-grade cows as rapidly as market conditions and natural increase in the breeding herd would warrant, and the purchase and use of pure-bred Hereford bulls. The purchase of pure-bred or better grade females was considered inadvisable. Twenty of the best bulls of each lot purchased were to be used with the selected 500 cows, to be replaced by better bulls as rapidly as additional purchases were made.

THE SPECIAL HERD OF 500 HEAD.

The special herd of 500 head was selected from the total of 1,950 cows of breeding age on the reserve during the summer of 1915. They were largely grade Herefords and generally showed the characteristics of the breed as indicated by the accompanying illustrations. (Pl. VII, fig. 2.) The ages in this herd varied from 3-year-old heifers to cows 10 to 12 years old. After selection the cows

[15] Jardine, James T., and Hurtt, L. C., Increased Cattle Production on Southwestern Ranges, U. S. Dept. Agr. Bul. 588, 1917.

were branded with a special brand for the herd, dehorned, and placed in a separate pasture.

In order to improve the grade of the herd as rapidly as possible the plan was to cull 10 to 15 per cent of the least desirable cows each year and replace them with good young heifers. Sixty-nine head were culled in the fall of 1917. These included a few cripples and two barren cows, while the rest were light-boned or otherwise lacking in desirable qualities or were past 11 years of age. They were replaced by an equal number of the best two and three year old heifers on the reserve, partly selected from the 1915 calf crop of this herd. It was thought best not to cull more heavily because of the possibility of decreasing the calf crop through introducing too many heifers. Sixty additional cows were culled in 1918, but no replacement was made at the time because of forage shortage and the prevalence of drought.

THE MAIN HERD.

After the selection of the 500 special cows, the remainder of the breeding herd consisted mainly of native or common stock and grades.[16] (Pl. V, fig. 1.) No less than 600 head, however, were off-color and Mexico stock.[17] Following the selection of the 500 head the main herd was worked over and 325 of the off-color and otherwise undesirable cows were cut out and marketed. In 1916, 101 head, and in 1917, 318 head of the least desirable cows were disposed of. These were replaced each year by 2-year-old heifers from the natural increase of the two herds. No culling was done in the fall of 1918 on account of interference with plans by an outbreak of scabies and the possible demand for breeding cows to restock ranges after the drought.

Average culling for the three years 1915 to 1917, inclusive, was at the rate of 12.6 head per hundred cows annually. By 1918, culling at this rate had resulted in marked improvement in grade and type of stock in the main breeding herd, aside from the improvement due to adding 2 and 3 year-old heifers. All the Mexico stock had been removed, as well as other off-colored, extremely light-boned, or otherwise undesirable cows. Approximately half of the herd consisted of white-faced stock, characteristically Hereford, the breed desired, and the rest were red and red-mottled-faced.

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[16] "Common" or "native" stock, as here used, is applied to offspring whose parents were of very poor breeding and uncertain origin. In "grade" one of the parents was pure bred and the other common or native; or both parents were well bred, so that offspring had over 50 per cent pure blood of a single breed.

[17] "Mexico stock," the long-legged, long-faced, slim-bodied, various colored stock coming originally from Mexico and the one-time characteristic range animal for northern Mexico.

Most of the bulls in the herd in 1910 were grade Hereford and Shorthorn, with a few pure-bred bulls. All of the Shorthorns were disposed of by 1914. After 1910 more registered Herefords and a few grades were purchased, and since 1915 none but registered Herefords have been procured. A lot obtained in the fall of 1916 came from breeders in the Panhandle of Texas, but since that time all bulls for the reserve have been purchased from breeders in eastern and central Kansas. Effort has been made to buy slightly better bred bulls each year in order to continue improvement through bulls as well as in selection of cows.

The best bulls in each lot have been used with the special 500 herd. Plate VI shows a number of the bulls used in this herd in 1918. Twenty head from the first lot of 26 head purchased in Kansas were placed in the herd in 1917. In 1918 the best from a lot of 89 head were selected to replace the poorest ones in the 20 originally placed in the herd. Sixty-eight of the best bulls from a lot of 88 head purchased in 1919 were selected for use on the reserve during 1920, and the best of these will be used to replace a few of the poorest in the special herd.

RESULTS OF THE SELECTION OF COWS AND USE OF GOOD BULLS.

The results of the selection of breeding cows and the use of good bulls are shown in the offspring. Over 96 per cent of the calves from the special breeding herd since 1915 have had good Hereford color and markings and for the most part good backs, straight tops and underlines, and have shown good beef conformation in general. Yearlings and 2-year-old steers have sold for from $2.50 to $5 more per head than the average in that vicinity, partly on account of improvement in grade, and fewer steers have been rejected by buyers because of poor grade or lack of uniformity. Plate VII, figures 1 and 2, shows the changes in type and grade of steers turned off the reserve following the improved breeding methods.

The accompanying photograph of yearling heifers (Pl. VIII, fig. 2), most of which are offspring of the selected herd, shows the grade of animal that is being produced. These heifers at 15 to 16 months of age averaged 534 pounds in weight before watering and after they had been off of feed for 24 hours. They showed much heavier bone, deeper bodies, wider backs, better developed loin and hind quarters than the average of either original herd, and approached more nearly the class of stock desired by the feeder.

RESELECTION OF HERDS IN 1919.

The net results from the work in improving the breeding stock from 1915 to 1919, especially the results from the special herd of 500 head, were so encouraging that during the summer of 1919,

F-22689-A

FIG. 1.—AN AVERAGE LOT OF THE BREEDING HERD ON THE JORNADA RANGE RESERVE IN 1915 BEFORE SPECIAL EFFORT HAD BEEN MADE TO IMPROVE THE GRADE OF STOCK.

The herd at that time was characterized by many light-boned and off-color cows.

F-36761-A

FIG. 2.—PART OF THE 500-HEAD HERD OF COWS SELECTED FROM THE MAIN HERD OF APPROXIMATELY 2,000 HEAD ON THE JORNADA RANGE RESERVE IN 1915 FOR SPECIAL BREEDING TESTS.

F-37735-A

PURE BRED HEREFORD BULLS PURCHASED FOR USE IN IMPROVING THE AVERAGE GRADE OF STOCK ON THE JORNADA RANGE RESERVE. GOOD BULLS ARE THE BASIS FOR IMPROVING THE GRADE OF CATTLE ON THE RANGE.

following the drought, the cooperator, Mr. C. T. Turney, decided to make a careful selection of breeding stock for both herds. From a total of 3,458 head of breeding cows and excess yearlings and 2-year-old heifers which had accumulated, 1,750 of the best cows and heifers were selected as the total breeding herd for the reserve. Of these, 387 head 20 months old and up were selected for the special herd, and 95 head of the best yearling heifers for a special test in breeding. The 1,263 head remaining at that time constituted the main breeding herd.

The cows and heifers for the special herd were selected with the object of securing the best individuals from the standpoint of breeding, conformation, and Hereford markings, regardless of whether they were offspring from the special 500 herd or the main herd of the reserve. The exact number of cows and heifers selected from the two herds for the new special herd was as follows:

Cows retained from original 500 herd inclusive of replacement	67 head=17.3 per cent
Heifers, offspring from the 500 herd	174 head=45.0 per cent
Heifers, offspring from the main herd of approximately 1,200 head	146 head=37.7 per cent

The total heifer branding in the experimental herd during the years 1916 and 1917 was 354 head and in the main herd 836 head, so that 49.1 per cent of the calves from the former were selected, while only 17.4 per cent of the latter were chosen. This is approximately 3 to 1 in favor of the herd in which greatest effort had been made to improve the grade.

At the same time 95 of the yearling heifers were selected for a special test. The best individuals were chosen regardless of the herd they originated in. Out of the 95 head, 69 were from the 200 heifers branded in the 500 herd in 1918. The remaining 26 head were from 302 heifers branded in the main herd in 1918. The ratio of selection is approximately 4 to 1 in favor of the offspring of the selected 500 cows.

In comparison with the original 500 special herd, the cows in the reorganized herd of 387 head are all as good or better grade individuals than the best of the former herd. The young cows show heavier bone, better development of loin and hindquarters, and greater beef conformation in general. Uniformity in grade and color is especially striking.

The general herd of 1,263 head are all characteristically Hereford, comparing favorably with the original 500 herd. As compared to the original main herd, all indications of common blood have been eliminated, with a decided improvement in bone and beef conformation. The greatest single mark of improvement is the elimination of

all off-color stock and the consequent striking uniformity of color and markings.

It is planned to continue building up these two herds as rapidly as possible from the offspring to a total of approximately 2,000 head. The plan will be to replace the poorest individuals in both herds with the offspring from the special herd and the best offspring from the main herd, with minimum interference with the calf crop from the introduction of too many young cows in the breeding herd at any one time.

INCREASING CALF CROP.

Where live-stock production is managed primarily on a breeding basis, as recommended for southern New Mexico, the ratio of cows maintained over a period of years to calves produced to selling age is of the first importance. If the average calf crop is 50 per cent or less, as it frequently is in this locality, an increase of 5 calves from every 100 cows may mean a decrease of 10 per cent in the cost of producing the average calf to weaning age. Management requirements of the stock on southwestern ranges, to avoid drought, warrant such effort as will most economically secure the greatest number of calves possible.

In connection with a study of live-stock production in the 11 Western States during 1914, data relative to calf crop over a period of years were obtained from stockmen for all of the western States, including the Southwest.[18]

Table 20 shows, by States, the average number of calves for each hundred cows, as well as the number of bulls for each 100 cows, as given by the schedules from stockmen.

TABLE 20.—*Average number of bulls for each 100 cows and average number of calves from each 100 cows.*

State.	Bulls.	Calves.	State.	Bulls.	Calves.
Arizona	6	57	New Mexico	5	66
California	3.73	73.55	Oregon	4.04	75.74
Colorado	4.16	69.3	Utah	4	69
Idaho	4	75	Washington	3.72	79.48
Montana	3.44	75.8	Wyoming	5.52	73.2
Nevada	4	70			

The average calf crop for southern New Mexico over a period of years does not exceed 50 per cent.

Table 21 gives the records of calf crop each year in southern New Mexico, estimated in connection with the investigations at the Jornada Range Reserve since 1916, and similar data for the whole

[18] Barnes, Will C., and Jardine, James T., Livestock Production in the Eleven Far Western Range States, U. S. Dept. Agr., Office of the Secretary, Report No. 110, Part II, 1916.

State since 1917, obtained from the Cattle Sanitary Board of New Mexico.

TABLE 21.—*Average number of calves for each 100 cows.*

Year.	Southern New Mexico.	Whole State.
1916	55	
1917	35	[1] 33
1918	25	30
1919	35	25
Average	37.5	29.1

[1] 50 per cent of usual calf crop.

The results obtained on the Jornada Range Reserve up to 1915 were no exception to the other ranges of New Mexico. The calf crop on the reserve in 1913 was approximately 48 calves per 100 cows; in 1914, 62; and in 1915, 52. The period 1913 to 1915 includes three good years, so that the average for the reserve prior to 1916, when a period of drought is included, did not, in all probability, reach above 50 calves per 100 cows.

Breeding stock on Arizona and New Mexico ranges are, for the most part, handled on the open range or in large pastures, making proper bull service difficult. Little or no effort has been made in the past to care for stock during the winter and spring, and cows very often go into the breeding season in poor condition. In the other States breeding stock are handled in smaller herds, thus facilitating bull service. Breeding stock are fed during winter and early spring and go into the breeding season in good condition. These differences in methods of handling stock in the Southwest and in other States are, no doubt, largely responsible for the yearly average of 16 calves less per hundred cows in Arizona, 23 less for the southern part of New Mexico, and 7 less for the whole State than the average for the other nine States.

CALF CROP ON THE JORNADA RANGE RESERVE SINCE 1915.

Investigations into the possibility of increasing the calf crop have been an important feature of the studies at the Jornada Range Reserve since 1915. The original plan was to study the comparative calf crop from a herd of approximately 1,500 cows run together, a herd of 500, and a herd of 42, all three under fence on the reserve, and the calf crop from range herds on similar range under prevailing open-range practice. The 500-head special herd and the 1,500-head herd were the same used in the general investigations, as well as in the demonstrations in improving the grade of stock, and have already been discussed under the latter heading. The large herd

consisted mainly of native stock from 2 to 12 years of age. The special herd was much the same in so far as age limits were concerned, but the cows were more nearly uniform grade Herefords. The 42 cows in the small herd were from 4 to 12 years of age, and were about the same as the special herd in grade. The drought in 1916 to 1918 interfered somewhat with the control of the separate herds, especially the herd of 42 head for which only one year's record is available. The results of calf crop obtained in the various herds on the Jornada Range Reserve and comparison with the estimated calf crop for outside range with average for the four-year period are shown in Table 22.

TABLE 22.—*Number of calves per hundred cows on open southern New Mexico range and on the Jornada Range Reserve.*

Year.	Outside range.	Jornada Range Reserve.			
		1,500-head herd.	500-head special herd.	42-head herd.	Average.
1916	55	69.2	81.0	.....	72.0
1917	35	52.7	68.2	.....	64.1
1918	25	50.8	80.0	97.6	58.8
1919	35	41.4	52.0	.....	43.7
Average	37.5	55.2	70.3	.....	59.6

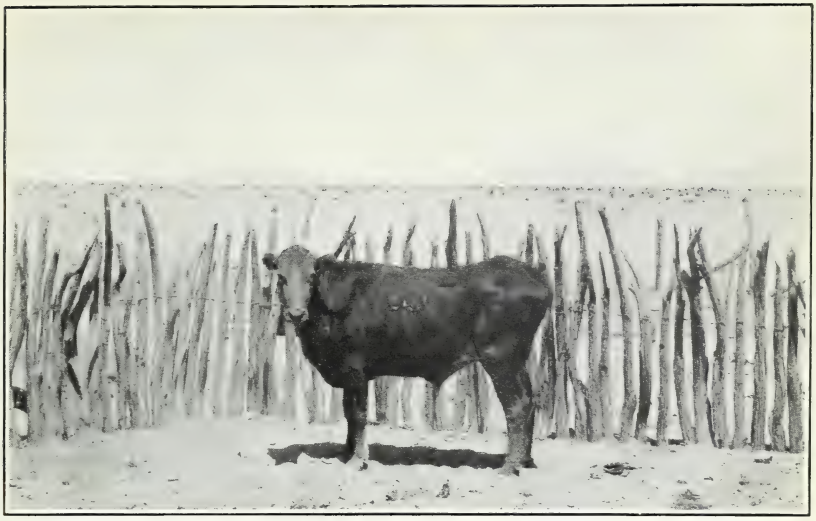
The larger calf crops of the Jornada reserve, as shown in the table, are the results of the methods of handling the stock in practice. These involve condition of the cows and bulls, number and distribution of bulls among the cows, and the segregation of nonbreeding stock from the breeding herd.

Condition of cows.—To insure the cows in the special herd being in thrifty condition for breeding and calving, grama-grass range was reserved for use by the herd during the winter and spring and supplemental feed was provided, as is shown in Table 23. In addition, the calves were weaned early, which gave the cows the advantage of being dry several months before the next calving time.

TABLE 23.—*Cottonseed cake fed and cost of feeding to cows in 500-head herd.*

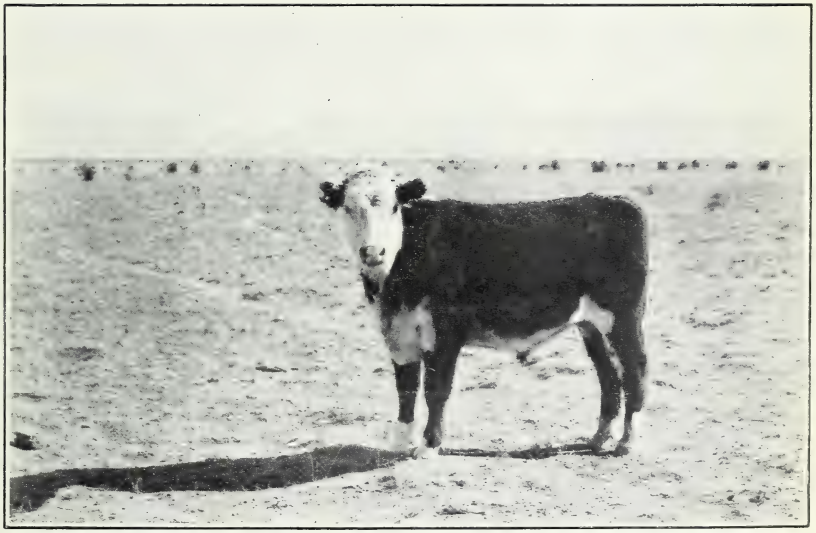
July 1 to June 30—	Number of cows fed.	Percentage of total breeding cows.	Amount cottonseed cake.	Total cost, feed and feeding.	Cost per head.	Cost per head for entire herd.	Period of feeding.
			Pounds.				
1915–16	[1] 371	52	25,650	$534.00	$1.44	$1.07	Feb. 1 to Apr. 26 June 6 to July 19
1916–17	220	44	22,585	649.32	2.95	1.60	Dec. 9 to Sept. 7
1917–18	500	100	64,500	1,935.00	3.87	3.87	Feb. 1 to June 15
1918–19 [2]	.....	.....	.....	.....	.....	.....	.....

[1] Includes 20 bulls. [2] No feeding.



F-37738-A

FIG. 1.—A 5-YEAR-OLD NATIVE STEER. THE OFFSPRING OF SCRUB PARENTS IS A POOR BEEF ANIMAL THAT BRINGS A POOR PRICE.



F-25901-A

FIG. 2.—A 2-YEAR-OLD GRADE HEREFORD STEER RAISED ON THE JORNADA RANGE RESERVE, THE RESULT OF EFFORT TO IMPROVE THE GRADE OF STOCK.

Note in general better beef characteristics as compared with Fig. 1. This type of animal is better suited to fattening for beef, and brings a higher price to the producer.

F-35690-A

FIG. 1.—A GROUP OF CULLS FROM THE MAIN HERD IN 1917.

F-42381-A

FIG. 2.—A GROUP OF YEARLING HEIFERS FROM THE 1918 CALF CROP, MAINLY FROM THE 500-HEAD HERD.

Disposing of the off color, poor grade, and otherwise undesirable cows and replacing them with the best 2-year-old heifers, the result of the use of pure-bred bulls, is the second step in the improvement of grade of cattle on the range.

As a result of the care given this herd, with but few exceptions the cows were in good, thrifty condition throughout the year. In the fall of 1916 some of the cows were not moved to winter range quite early enough and feeding them cottonseed cake was reduced early in 1917, so that they were somewhat under the condition they should have been in at that time. This is believed to account in part for the low calf crop in this herd in 1917. No feeding was considered necessary in the winter and spring of 1918–19, as the cows entered the winter in excellent shape and had an excess of good range forage during the whole period. With the exception of the fall and winter of 1916–17, 95 per cent of the cows were in good, thrifty condition at all times of the year.

The main herd on the reserve, of approximately 1,500 head, was given some special attention to maintain the cows in good physical condition, but not so much as was given the special herd. In the spring of 1916, 5.1 per cent of the cows were fed at the rate of 8 cents per head for the whole herd, 13.1 per cent at the rate of 32 cents per head in 1917, and 85.4 per cent at the rate of $3.03 per head in 1918. Calves were weaned when from 8 to 10 months of age, except in 1917, when all calves down to 4 months of age were weaned in October. Range was reserved for only the poorest cows during the winter and spring of each year. The feeding and other care given the cows in this herd was primarily for the purpose of avoiding loss from starvation rather than of increasing the calf crop. The cows not fed, therefore, varied from those that were very poor but would probably pull through on the range without feeding until green grass came to dry cows that were in thrifty condition. Those that were not in thrifty condition included some not being fed as well as those on feed, and the number of unthrifty stock varied with the intensity of the drought.

The drought and lateness of the season in 1917 resulted in many of the cows in this herd not getting into condition to breed that year. The small amount of forage produced resulted further in a scarcity of range feed for the winter and spring, so that over 85 per cent of the cows had to be fed to keep them alive. The drought did not break until August of 1918. Therefore, a large percentage of the cows did not get into condition to breed for the 1919 calf crop before the severe winter set in. Although the drought was over before 1919, the calf crop that year was smaller than the previous year because the cows were in weaker condition and fewer were bred in 1918 than in 1917. The difference in condition of the cows in this herd as compared with the special herd probably accounts in a large measure for the difference in the calf crop in the two herds. However, the care and feed given the large herd to prevent loss from starvation had its advantage, since the calf crops obtained were

larger than in outside herds where little or no special attention was given to avoid loss from starvation.

Bulls, number and distribution.—Four bulls per 100 cows have been used in both these herds each year. All were strong, vigorous bulls, ranging from 2 to 7 years of age, and all those brought from other States were acclimated to the range for six to nine months before being turned into the herd. Each winter and spring all bulls not in good condition were fed cottonseed cake, with pasturage and other feed if necessary, to have them in what was considered good breeding condition for the main season. The amount of feed varied with the condition of each animal, but an average of 1½ to 3 pounds of cottonseed cake per day was fed each bull for five or six months while on good dry pasturage.

The main breeding season occurs from late in July until October, and all the bulls were with the cows during this period. At other times of the year, however, a few of the more thrifty were left with the breeding herd. There is some question as to the advisability of leaving bulls with the cows yearlong, especially as more feed and better care in general is given the breeding herd; but there has been less question in the past, since stockmen operating under old methods felt that the growing seasons were too erratic to confine the breeding season to any one period of the year.

Except in 1918, special attention was given to distribution of bulls among the cows in the special herd. During the breeding season of the other years the 500 head of cows and 20 bulls were run by themselves in a pasture of 17,000 acres where there were four watering places. Besides being in this comparatively small pasture, a cowboy spent about three-fourths of his time during the main breeding season seeing to it that there was the proper number of bulls in proportion to the number of cows at each watering place.

The drought interfered with the regular procedure in handling this herd during the breeding season of 1918. The cows were moved to a brushy pasture of 74,714 acres, and no effort was made to keep the bulls distributed by riding after them. To this poor bull distribution is attributed the exceedingly low calf crop in this herd in 1919, for the cows were in excellent condition at all times and other factors were favorable.

The large herd was kept in a large, brushy pasture of 74,714 acres during the breeding season of each year except in 1918, when, owing to drought, they were removed to a much larger area of outside range. No effort was made at any time to keep bulls distributed by riding, and with 12 watering places in the pasture and more on the outside range, bull distribution was not as good as it might have been. Plate IX, figure 1, shows what may happen if no effort is made to keep bulls distributed. At that, however, there was some advantage in

having the cattle in the pasture as compared with outside range where stock were scattered over much larger areas with only four bulls per hundred cows. This poor bull distribution and difference in condition of the cows at critical times as compared to the special herd are mainly responsible for the difference in calf crop in the two herds.

The 42-head herd.—The drought interfered with the handling of the 42-head herd, but the results of one year have great significance in the possibilities of increasing the calf crop. The cows in this lot were run by themselves during the main breeding season of 1917 in a fairly large pasture with but one bull, but all came to a single watering place every day or every other day, so that the bull came in contact with all of them. The condition of these cows was about the same as in the 500-head herd, the 42 cows being fed during the winter as part of the special herd.

All but one of the 42 cows brought calves in 1918. While it is not safe to draw conclusions from a single trial, the results in this herd of cows indicated the possibility of securing large returns in calf crop when efficient bull service is assured and the cows are kept in good condition.

CALF PRODUCTION SUMMARY.

The calf crop for all the herds on the Jornada Range Reserve for the period 1916 to 1919, inclusive, shows an average of 22 calves more per 100 cows, or 60 per cent greater production than the average in herds on other range in the vicinity where little or no attention is paid to condition of breeding stock, distribution of bulls, and other influencing factors. The average in the special herd is 32.8 calves more per 100 cows, or 87 per cent bigger calf crop. The greatest variation is 80 calves per 100 cows in the special herd on the reserve in 1918, as compared with 25 calves for the same number of cows on outside range. These results are due mainly to provision of sufficient winter range and supplemental feeding during the critical period of the year and greater care in the distribution of the bulls. Comparisons of the results in different years in the various herds on the reserve further emphasizes the importance of these factors. The largest calf crop has been obtained each year in the special herd, with the exception of the one year's record for the 42-head herd. In the special herd, however, there was a marked drop in 1917, when the cows were allowed to get poor for a short period during the latter part of the breeding season of 1916. Again, in 1919, 28 calves less per 100 cows than the maximum average of 80.5 calves for 1916 and 1918 is thought to be due entirely to the lack of a sufficient number of bulls for the size of pasture the herd was in and the lack of riding to keep the bulls properly distributed during 1918.

Constant use of the better methods should result in a calf crop of not less than 70, or more nearly 80, calves per 100 cows each year on the ranges of the Southwest, instead of the usual 50 or 60 calves under present methods. So great an amount as $3.87 per cow per year for feed and provision of adequate winter and spring range, as well as the small additional expense for proper bull distribution, are warranted when they affect calf crops so materially. Four bulls per 100 cows are insufficient unless stock are handled in small lots during the breeding season, and bull distribution is attended to by range riding on large ranges. With expensive, high-class bulls, fencing to control stock on small areas and riding to distribute bulls will doubtless be found more economical than the use of more bulls.

Segregation of breeding stock from nonbreeding stock is of importance in obtaining better bull service and should not be lost sight of in efforts to obtain more calves per 100 cows. In addition, it is probable that heifers under 20 months of age should not be bred under southwestern range conditions, as they usually skip the following year or require additional feed to prevent stunting. After a cow passes 11 or 12 years of age she usually begins to decline in productiveness and there is danger of heavy expense in feeding her through the spring, so that it is best to dispose of cows when they reach this age.

FUTURE PLANS FOR INCREASING THE CALF CROP ON THE JORNADA RANGE RESERVE.

The results to date on the Jornada Range Reserve justify continuing the methods of management and even intensifying them. In the future it is planned to increase feeding in the various herds to where all stock will be in better breeding condition, and also eventually to divide the range for the main herd so that the cows will be confined in a smaller area during the main breeding season, and in this way insure better bull service, as well as provide fresh range for winter. The herd of approximately 500 head will be handled much the same as previously, with more riding to keep bulls distributed. The herd of less than a hundred head will be continued in order to secure more conclusive data on the value of small herds.

To determine the effect of breeding heifers to calve at 2 years of age, 95 yearling heifers were placed in a separate pasture and bred in 1919. Careful records will be made of the number of calves dropped, rate of growth of calves and heifers, and cost of feeding each year. They will be compared with a number of heifers not bred to calve until 3 years of age. Records for the two herds will be maintained long enough to obtain data as to the effect over a period of breeding heifers to calve at 2 years, compared to breeding them to calve at 3 years of age.

F-35687-A

FIG. 1.—SEVEN BULLS AT A SINGLE WATERING PLACE WITH ONLY 45 COWS. THIS ILLUSTRATES WHAT MAY HAPPEN IF MEASURES ARE NOT TAKEN TO KEEP BULLS DISTRIBUTED ON THE RANGE.

Good results may be obtained with 1 bull per 25 cows on level range if bulls are kept well distributed by riders.

F-45573-A

FIG. 2.—COWS, AND ESPECIALLY HEIFERS WITH YOUNG CALVES, LIKE THESE, CAN PROFITABLY BE FED A SMALL AMOUNT OF COTTONSEED-CAKE DURING THE SPRING BEFORE GREEN FEED OCCURS IN ORDER TO MAINTAIN MILK FLOW AND HAVE THE COW IN CONDITION TO BREED AND BRING A CALF THE FOLLOWING YEAR.

F-152750

FIG. 1.—FEEDING EARLY WEANED CALVES A SMALL AMOUNT OF CONCENTRATED FEED TO SUPPLEMENT THE RANGE FORAGE WILL MAINTAIN THEM IN BETTER CONDITION THAN IF THEY FOLLOW THE COW THROUGH THE WINTER.

There is less danger of loss among the cows and they will be in better condition to calve the next year.

F-37743-A

FIG. 2.—FEEDING CHOPPED SOAPWEED WITH COTTONSEED MEAL TO POOR STOCK ON THE VERGE OF STARVATION IN TIME OF DROUGHT.

When drought is prolonged and the reserve supply of range is nearing exhaustion, feeding of some roughage may be advisable. Soapweed (*Yucca elata*) is of value as emergency feed over large areas of the Southwest.

DECREASING LOSSES OF CATTLE.

The average annual losses of range cattle in New Mexico for the entire State for a series of years are approximately 7.3 per cent;[19] for southern New Mexico, about 10 per cent. The New Mexico Cattle Sanitary Board[20] estimated the total loss of cattle in New Mexico during the drought of 1916–1918 and the hard winter of 1918–19 as 25 per cent of all cattle in the State, "the heaviest loss on record in a similar period." This loss was in spite of heavier shipments of cattle from the State during 1917 and 1918 than for any two years previous. Losses for range similar to the Jornada reserve and in the same locality are estimated at 12 per cent in 1916, 15 per cent in 1917, and 35 per cent in 1918. Analysis of these losses will show that they are due mainly to starvation, directly or indirectly, disease, poisonous plants, and predatory animals—all more or less preventable. Obviously, reduction of the heavy losses on southern New Mexico and similar range is a necessity if live-stock production is going to be profitable under increased value of stock and range, large expenditures for range improvements, and increased labor costs. The problem of reducing losses has been attacked vigorously within limits of economy at the Jornada Range Reserve and the results are considered exceptionally encouraging, considering the large unit under management and the many problems encountered.

REDUCTION IN LOSS FROM STARVATION.

Starvation due to forage shortage, especially in time of drought, has been the main cause of losses among cattle on the Southwestern ranges in the past. As the forage supply on range is reduced in amount or becomes low in nutritive value during winter and spring before the rainy season begins, cattle, especially breeding cows, slowly lose flesh until they become so emaciated that they very often die. In their weakened state they often get stuck in bog holes or die calving, and all such losses are indirectly chargeable to starvation.

Occasionally, but very rarely except in the high mountain country, heavy snows may occur that cause injury to stock. Sometimes losses are caused by stock thirsting for water, when well equipment breaks down or springs or water holes go dry unexpectedly. Losses from lack of water usually indicate failure to keep equipment in good shape, to move cattle before the water holes dry up, or poor

[19] Barnes, Will C., and Jardine, James T., Livestock Production in the Eleven Far Western Range States, U. S. Dept. of Agr., Office of the Secretary, Report 110, Part II, 1916.

[20] From extracts from Report of Secretary of the New Mexico Cattle Sanitary Board for year ending Dec. 1, 1919, to the Governor of New Mexico, printed in El Paso Livestock Journal, Mar. 1, 1920.

business foresight in not keeping a supply of water ahead of the daily requirement for use in an emergency.

Adjusting livestock production to the amount of forage produced over a period of years, as already discussed in preceding chapters, is expected to guard against the serious losses in time of extended drought. Within each year, however, from February or March to the beginning of the summer rains, is a period when there is great danger of loss from starvation. The available dry forage is low in nutritive value and the point of full utilization of the year's supply is being neared. Stock are normally in their poorest condition at this time of the year. In any herd on a fully stocked range there will always be a number of unthrifty cows among which losses will be heavy unless steps are taken to prevent it. Measures to prevent such losses are essential in addition to the plan for maintaining the permanent herd over a period of years, and constitute a secondary step in the whole plan to guard against losses from starvation. The principal measures taken to avoid loss from starvation on the Jornada Range Reserve have been reserving a supply of range forage for use by needy stock during the critical period of the year, proper distribution of water, early weaning of calves, supplemental feeding, and care in handling stock.

Reserved range feed.—The first step in providing for the critical period of the year has been to reserve a sufficient portion of range that is suitable for winter use for poor stock during the period January to July, as previously stated. Pastures 3 and 8 and part of pasture 7, all of which are principally grama grass and browse range, are held until winter and then used by poor stock from the main breeding herd. Pasture 2 is held for use by the main breeding herd in time of drought, and also for needy cows in this herd during spring. The animals in the large pasture are watched during winter and spring, and needy ones transferred to the small pastures where there is better forage. In the springs of 1916 and 1917 about 4 per cent of the cows in the main herd were transferred to these pastures. During the same period in 1918, the worst of the drought, these pastures were utilized for carrying the poorest stock. Having this supply of reserve forage available for use by the poorest stock played an important part in reducing losses in this herd.

The special herd on the reserve is provided for in pasture 13 during summer and fall. Beginning in early fall, the cows were carefully watched, and as soon as one began to get poor she was transferred to the winter range in pastures 10 or 7. This gave the poor cows the advantage of having fresh range and shorter distance to travel to water, which avoided much of the danger of loss. Complete utilization of the summer range by the stronger cattle was then obtained.

Water development.—Proper number and distribution of watering places plays an important part in keeping cattle in condition that will prevent losses. Naturally, where the distance between waters is great the feed near water is utilized first; then, later on, when the stock are poorest, they are compelled to travel great distances from water to feed, so that much time and energy are wasted. Losses on the outside range adjoining the reserve on the west, where watering places are 7 to 12 miles apart, were heavy in 1916, 1917, and 1918, largely on account of the weak stock having to travel so far from water to feed. As they grew weaker they were unable to travel out to where feed was good, and soon became so weak that they died. Having the watering places 5 miles or less apart will secure more even utilization of the range and weak stock will not have to travel so far to water.

Early weaning and feeding of calves.—Obviously, a cow will not do as well on the range when she is suckling a calf as when she has only herself to provide for. Weaning calves as soon as they are old enough, therefore, should be a decided advantage in maintaining cows in better condition on the range.

The practice on the Jornada Range Reserve in the average year has been to wean the calves during early winter when they are from 6 to 10 months of age. Plate X, figure 1, shows a number of calves on feed. In 1917, during the drought, all calves down to 4 months of age were weaned in October. When the calves were weaned the cows were turned back on the range, and fewer of them required feed or additional care than would otherwise have been necessary.

Early weaning of calves, even down to 4 months of age, has been made possible by feeding. Ordinarily, calves are weaned at 6 to 10 months of age. The earlier weaning has been limited to calves from a small percentage of cows, except in 1917. The number of calves fed, the amount and character of feed, and cost of feeding are given in Table 24.

TABLE 24.—*Number of calves fed, character and amount of feed, and cost of feeding.*

Year.	Number of calves fed.	Character and amount of feed.	Cost of feed and feeding.	Cost per head.
1916	[1] 700	37.2 tons cottonseed cake	$1,722.10	$2.56
		4.5 tons alfalfa	72.50	
1917	[1] 746	52.5 tons cottonseed cake	3,018.01	4.71
		69.5 tons ensilage	495.50	
1918	873	488 tons ensilage	3,466.00	9.14
		48.9 tons cottonseed meal	2,936.00	
		Valley pasturage	1,577.00	

[1] Includes half heifers and half steers.

The feeding of cottonseed cake to older calves in 1916 and 1917 was largely to prevent them from becoming stunted. Although they

did not make much growth from the time of weaning until green grass came the next spring, the small amount of cottonseed cake kept them in condition to respond readily when green feed came and prevented loss from weakness or starvation.

Calves under 6 months of age were fed corn and cane ensilage and cottonseed meal at the rate of 14 pounds of ensilage and three-fourths pound of meal per day. The extra feed was given the young calves to avoid the danger of stunting by leaving them on the range when weaned so young. The feeding of cottonseed cake only would not have been sufficient to prevent stunting. This feeding cost an average of $9.14 per head in the fall and winter of 1917–18.

There is little question that feeding at the rate of $2.56 per head or even $4.71 is a good business investment, as was apparent in the sales of a part of the steer calves fed. In May, 1916, 100 head of long yearlings from the 350 steers out of the total of 700 heifers and steers weaned early in the previous winter and fed, were placed with the two-year-old steers and sold at regular two-year-old prices. At that time there was $10 difference between the prices of a yearling and a two-year-old steer. In the spring of 1917, about 40 head were sold in the same manner, and 100 head were sold at two-year-old prices in the fall of 1917 when 18 months old. However, a part of this is also to be attributed to improvement of grade. Heifer calves, fed, made similar gain, showing the advantage to the calf of feed and extra care. Even so great an expenditure as $9.14 per head in 1917–18 is not thought unwarranted when everything is considered. The calves fed were all heifers, and no sales were made, but they made normal gain and were up to the average weight for yearlings in June, 1918, while calves that followed the cows on the range were 25 per cent underweight at that date. A great advantage is given a cow when she is allowed the benefit of being dry several months previous to and during the most critical part of the year, and no small part of the success in keeping down the losses on the Jornada Range Reserve since 1915 is attributed directly to early weaning of the calves.

Supplemental feeding.—In any herd, no matter how much dry winter forage is available, there will always be at least a few unthrifty cows that may be lost if left to shift for themselves on the range. There might also be times when reserve forage or other measures may be insufficient to meet the demands for keeping down losses. Under these circumstances the use of supplemental feeding, in so far as it is economical, will assist in keeping down loss.

Feeding of cottonseed cake to poor cows.—When cows have become very poor and weak and the dry winter forage is too low in nutritive value to save them from starvation, a small amount of concentrated feed to supplement the range forage will make a better balanced

maintenance ration. Cottonseed cake has been used to supplement the range forage each year on the Jornada Range Reserve.

Table 25 shows the actual number and per cent of total herd, amount of cottonseed cake fed to supplement range forage, and cost of feeding, for the main breeding herd of approximately 1,500 head on the Jornada Range Reserve, 1915 to 1918.

TABLE 25.—*Records of supplemental feeding of cottonseed cake with range forage to cows from the main herd of approximately 1,500 head.*

Year.	Number cows fed.	Per cent of cows fed.	Amount cotton-seed cake.	Total cost of feed and feeding.	Cost per head fed.	Cost per head entire herd.	Period of feeding.
			Pounds.				
1915–16	[1] 74	5.1	5,900	$118.00	$1.59	$0.08	Feb. 1–Apr. 26.
1916–17	[1] 200	13.1	16,885	485.45	2.42	.32	Dec. 18–Aug. 7.
1917–18	[2] 1,296	85.4	59,424	1,772.72	1.39	1.19	Jan. 1–July 31.
1918–19[3]							

[1] Includes some bulls. [2] Includes only breeding cows. [3] No feeding.

The number of stock, amount of feed, length of feeding period, and cost of feed will depend largely upon the year and feed prices. In the spring of 1916 the period was comparatively short, because of rains in April and May. The years 1917 and 1918 were very dry years and the feeding period was longer. In 1918 the ranges were considerably overstocked, which accounts in part for the excessive feeding that year.

As pointed out under increasing the calf crop, the 500-head herd was fed to maintain them in thrifty condition for breeding. When the herd is kept in this condition there is, obviously, less danger of loss from starvation.

Feeding of roughage.—In case of prolonged drought the supply of range feed may near depletion or become entirely exhausted. To meet such emergencies some supply of roughage will be of advantage. Such a supply of forage is limited to (1) native forage plants that are unusable in their native state but may be prepared into feed; (2) forage crops raised under irrigation; (3) dry-land forage crops raised during wet years and stored for emergency purposes. Of these, feeding prepared from native forage plants offers the best possibility thus far.

Feeding of soapweed.—The use of soapweed as emergency feed (Pl. X, fig. 2) was first started on the Jornada Range Reserve in 1915 by making ensilage out of the tops of the plants.[21] When fed in 1916, 1917, and 1918 this ensilage gave very satisfactory results. During the fall of 1917 machinery for cutting soapweed was developed, and

[21] Jardine, James T., and Hurtt, L. C., Increased Cattle Production on Southwestern Ranges, U. S. Dept. of Agr., Bul. 588, 1917, p. 26.

extensive use was made of this plant as feed in the spring of 1918. Complete details for handling and feeding this plant are given in another bulletin.[22]

A total of 353 tons of chopped soapweed and 47,090 pounds of cottonseed meal was fed in feeds of 15 to 20 pounds of soapweed and 1 to 1⅓ pounds of meal per day, to a total number of 845 head of cows from the main breeding herd between January 20 and June 11, 1918. Some of the stock were on feed the entire period, and others were fed only a part of the time. Poor cattle fed this amount of soapweed and cottonseed meal daily were maintained with very little loss, and part of the stock gained slightly.

The cost of feeding soapweed and meal was $3.23 per head actually fed, or $1.84 per head when the entire main herd is considered. The cost of preparing the soapweed was $3.72 per ton,[23] and cottonseed meal, including labor in feeding, cost $60 per ton. The average daily ration of prepared soapweed and cottonseed meal cost approximately 7 cents per day.

The slow growth of this plant and the time required to replace a stand of soapweed, once it has been cut, however, warrants its use only as an emergency ration, at least until more definite information is available to determine the actual time required for replacement.

The use of forage from irrigated farms will depend upon the availability of such forage and the cost of feeding. During 1918, 873 weaned heifer calves were fed ensilage on a farm in the Rio Grande Valley, adjacent to the reserve, at the rate of 14.3 pounds of ensilage and 0.8 pound of cottonseed meal per day for a period of approximately 85 days. The ensilage cost $7 and the cottonseed cake $60 per ton. This was at the rate of $2.22 per month for a calf. A grown cow would require at least 17 to 20 pounds of ensilage and a pound of cottonseed meal per day, which would cost $2.70 to $3 per month for feed alone, on the basis of prevailing prices of ensilage and cottonseed meal in 1918. Under southwestern range conditions, such high prices for feed are warranted only in case of extreme emergency and for short periods.

Dry-farming forage crops have been raised under conditions of slightly better rainfall than prevails in southern New Mexico, but little or no success has been obtained where the average annual rainfall is as low as at the Jornada Range Reserve. Raising forage crops in southern New Mexico in the average year is a possibility

[22] Forsling, C. L., Chopped Soapweed as Emergency Feed for Cattle on Southwestern Ranges, U. S. Dept. of Agr., Bul. 745, January, 1919.

[23] The cost of converting soapweed into feed was $2.27 per ton in 1918, when equipment and labor were operating satisfactorily. On account of imperfection and difficulty in obtaining skilled labor there were often long delays and loss of time which resulted in an average cost of $3.72 per ton.

only under better methods of nonirrigated farming than are now known. However, in the wettest years over most of the Southwest there is sufficient moisture to raise a fodder crop, especially on areas flooded by the run-off from nearby hills. Fodder raised in these years and cut green and stored in a silo, if in sufficient quantity, would constitute a valuable supply of reserve feed. Crops of the sorghum group were raised successfully in the vicinity of the Jornada Range Reserve in 1913 and 1914. A pit silo with a capacity of 250 tons was constructed at a cost of $300 on the reserve in 1915 for storing soapweed. Such a silo could also be used for storing ensilage, and several of them located at strategic places on the range and filled with feed would be an excellent assurance against losses during drought.

Feeding of roughages at best is an expensive proposition, and requires care in order that costs may not become excessive. The greatest care, perhaps, may be exercised in judicious planning to begin feeding a small portion of the stock early enough to relieve the range somewhat and thus avoid the necessity of feeding a large number of stock later. A smaller number can be handled for a long period much more economically than a larger number for a short time.

Handling poor cattle.—A great deal of the success and economy in the results from measures taken to avoid losses depends upon the way the cattle in poor condition are handled. Good results can not be expected where poor cattle are left to compete with stronger individuals for feed and water. Unwarranted rounding up, rough handling, and constant moving are detrimental to cattle and should be avoided; but, as some handling is necessary in getting the animals to feed and in grouping them for feeding, it should be done slowly and carefully.

The best results have been obtained on the Jornada Range Reserve when the poor cows were segregated from the stronger stock and fed according to their requirements. In the spring of 1918 the poor cattle were divided into several different lots, varying from very poor cattle almost "on the lift" to stronger dry cows that subsisted on dry range forage alone. Each lot was carefully watched and weaker cows placed where they would receive more feed, or stronger cows removed from the feed lot, as the case might be. This was accomplished by slow, careful working of the stock when they were at watering places, thus avoiding rounding up or running them. When it was necessary to move poor stock any distance it was done by slow, careful handling with minimum ill effect. They would be moved only short distances each day and then allowed to rest and graze, or were fed. Constant riding and looking after stock made it possible, in most cases, to note the condition of poor individuals in sufficient

time to get them on feed before there was danger of their starving to death. Riding among and handling range cattle may have a slight tendency to disturb and annoy them, so that they may not do so well at first. This has even led some stockmen to the opinion that it is best to disturb them as little as possible. Experience has shown, however, that this is true to a slight extent only with the native cattle, and that the better grades which have practically replaced the native stock have now become accustomed to handling and are not injured by it, providing it is slowly and carefully done. Even timid cattle soon learn to come to feed, and if carefully handled receive the full benefit from it.

Comparison of starvation losses.—The measure of results from the steps taken to avoid losses from starvation is shown by a comparison of the losses of stock that have occurred on the Jornada Range Reserve since the problem was attacked, and losses under open range conditions in southern New Mexico for the same period. Such a comparison is made in Table 26.

TABLE 26.—*Losses of live stock from starvation on the Jornada Range Reserve and on open southern New Mexico ranges.*

Year.	Jornada Range Reserve.		Open range.	Entire State.[1]
	Main herd.	500 special herd.		
	Per cent.	*Per cent.*	*Per cent.*	
1916	0.3	0.0	12	
1917	1.0	.4	15	25 per cent of all stock in the State.[3]
1918	2.5	.4	35	
1919	[2] 1.0	.0	5	
Average	1.2	.2	16.7	

[1] Data furnished by Cattle Sanitary Board of New Mexico. Losses heavier in northern part of State because of severe winter of 1918–19.
[2] Herd on the reserve only part of the year, but figure applies to whole year.
[3] Although this figure includes some losses from other causes, losses are mainly due to starvation.

Records for losses on the Jornada Range Reserve are made from actual observations of stock that died. Since poorest stock are handled in small pastures and around feed lots, and the entire range covered by riders many times during each year during round-ups and on other occasions, very few dead stock are missed. The records for the outside are compiled from careful estimates from observation by stockmen and others connected with the livestock industry, and are considered reliable.

The comparatively low losses on the Jornada Range Reserve in the main herd are attributed directly to the method of management to provide for needy stock during the period from January until rains occur in the summer, and to reducing the number of stock on the range in time of drought. The additional cost for feed was not

excessive. So great an expense as $3.03 per head is not unwarranted so long as losses are kept down and the calf crop is more nearly that in average years.

There was practically no feeding in 1919, when the breeding herd was scattered over an adjoining open range where there was a reasonable amount of winter forage. The 1 per cent loss which occurred would largely have been avoided had the few poor cows been picked up and placed on feed.

The cows in the special herd were fed and given better care than other stock on the reserve, the cost of feed amounting to $3.87 per head in 1918. Care was exercised not to overstock the range and to provide reserve range for winter and spring use. These cows were maintained in thrifty condition for breeding, and the calf crop was materially increased. Maintaining them in this condition has resulted in reducing the loss from starvation to less than one per cent in four years.

There is no doubt as to the justification of the additional care taken and feeding which has been done in the main herd on the Jornada Range Reserve. The saving in the reduction of losses alone, as compared to losses on open range, will more than pay for the feed and care, to say nothing of a slight increase in calf crop. The part which even greater feeding of stock has played in increasing the calf crop 10 to 20 calves per 100 cows and almost eliminating losses from starvation in the special herd indicates that even greatly increased feeding in the main herd would be warranted. The amount of feeding and care that will be more than paid for in decrease of loss and in increase of calf crop has not been exceeded even in the special herd, and it is doubtful whether it has even been reached.

Reserving range with an adequate water supply for use during winter and spring may be considered the basis of management, and handling stock to avoid losses from starvation with the other steps as supplemental. Without such a supply of forage the cost of feeding becomes excessive, and other measures have less value. With the range forage available supplemental feeding is practical; but without it feeding must include the use of roughage as well, and such feed at a reasonable price is extremely limited in the semidesert country.

The principal requirement of the range to be reserved for winter use is that it contain a suitable class of forage, such as grasses that cure on the range and make good winter feed, and palatable browse, with an adequate water supply. Black grama and other grama grasses are the principal grasses valuable for this purpose in the Southwest. Where other grasses are present they should be used for summer range.

REDUCTION IN LOSS FROM DISEASES AND PARASITES.

Blackleg.—In the past blackleg has been the main cause of losses from disease. In May, 1915, for example, 50 head of yearling steers died of blackleg in one herd of about 1,000 head. All yearlings were vaccinated immediately and losses stopped. Systematic vaccination of all stock between the approximate ages of 5 months and 20 months was started in the fall of 1915, and has been continued since.

The Government blackleg vaccine was used the first two years, with special care to secure proper preparation and administration. All stock of the more susceptible age [24] were vaccinated twice and sometimes three times a year, usually during fall branding and once or twice in the spring. The experience with the Government vaccine has been that a high per cent of immunity resulted from vaccination, but that the period of immunity was short, usually from 3 to 6 months.

The loss attributed to blackleg on the Jornada Range Reserve among calves vaccinated with the Government vaccine in 1916 and again in 1917 was approximately 1 per cent for stock 5 to 20 months of age. These results are very good as compared with the 5 per cent loss in one month in 1915, before vaccination was started. The Government vaccine requires rather frequent administration, however, and the cost of rounding up and jamming the cattle incident to vaccination two or three times a year is no small item.

Since the fall of 1917, all calves have been vaccinated with a germ-free serum developed at the experiment station of the Kansas Agricultural College. This vaccine has been administered to calves 4 to 5 months of age and up, during fall branding and during weaning time in winter. Each calf vaccinated is marked by "bushing" its tail to distinguish it from those that have not been vaccinated. Where calves are not weaned but left on the range good results have been obtained by working the stock at watering places for several days, vaccinating the calves and yearlings and turning them back on the range.

Since 1917, in so far is it has been possible to determine, no calves or yearlings treated with this vaccine have died from blackleg. A few losses attributed to blackleg occurred when the work was delayed and some calves reached the susceptible age before being vaccinated. Undoubtedly some deaths occurred also among calves that were missed. The loss from this disease has been reduced to less than 0.1 per cent of stock of susceptible age with the use of the improved vaccine.

Systematic vaccination is possible under open-range conditions, and the good results obtained from both the Government vaccine and

[24] Calves 5 to 20 months of age are considered more commonly susceptible to blackleg, but stock both older and younger have been known to die from the disease.

the germ-free vaccine when properly and carefully administered certainly warrant the attention of all stockmen in eliminating the losses from this disease.

Scabies.—An outbreak of scabies in the herds on the reserve in 1919 contributed materially to the poor condition of the stock that year. The disease caused stock to fall off in flesh rapidly, causing danger of loss from starvation. The infestation of stock on the Jornada Range Reserve was cleaned up in a single dipping campaign of two dippings in lime-and-sulphur dip at intervals of 11 to 14 days, under the direction of the United States Bureau of Animal Industry. A detailed description of the disease and treatment is given in Farmers' Bulletin 1017.[25]

Parasites.—The two most common parasites on cattle on southwestern ranges are the louse and the spinose ear tick. They are most prevalent during winter and spring months, when stocks are in the poorest condition. While these parasites do not cause death directly, they lower the vitality of the stock by drawing nourishment from the blood of the host and detracting from quiet grazing through constant irritation, thus contributing indirectly to losses by starvation.

Both long-nosed and short-nosed ox lice are common on Southwestern ranges. These parasites spread rapidly where cattle are handled on feeding grounds. Dipping in arsenical or nicotine dip is recommended by the Bureau of Animal Industry for control of lice on range cattle. A single dipping of year-old stock in low-strength arsenical dip just before they were removed to summer range on the Jornada Range Reserve in 1917 was effective in checking the lice infestation, thus giving the stock additional advantage on the range.

As many as 110 ear ticks have been taken from the ears of one yearling heifer on the Jornada Reserve. The injury caused by these ticks in drawing blood from their host and the constant irritation contribute in no small degree toward weakening a poor animal. A mixture of two parts pine-tar and one part cottonseed oil, in doses of about one-half ounce, applied to the ears of the infected animal, as recommended by the United States Bureau of Animal Industry to check the ear tick, has been used to some extent on stock on the Jornada Range Reserve. Treated animals were rid of the pest for a sufficient period to be of value in improving their condition, but reinfestation usually occurred in from 2 to 7 weeks. The ticks live apart from their host for long periods, and stock pick them up around watering places, corrals, etc.

[25] Imes, Marion, Cattle Scab and Methods of Control and Eradication; U. S. Dept. Agri., Farmers' Bul. 1017, December, 1918.

More complete information will be found on both lice and ear ticks in publications by the United States Bureau of Animal Industry.[26]

REDUCTION IN LOSS FROM POISONOUS PLANTS.

There are a number of poisonous plants on the semidesert ranges of southern New Mexico. Among these may be mentioned two suspected species of *Astragalus*, rattle-weed loco and blue woolly loco,[27] which occur on and in the vicinity of the Jornada Range Reserve.

Heavy losses among both cattle and horses on range adjacent to the Jornada Range Reserve were attributed to the rattle-weed during the winter and spring of both 1917 and 1918. The range was so closely grazed that there was little other forage available, and both classes of stock ate the rattle-weed freely. The same species occurs to a considerable extent on the Jornada Reserve, but other forage was always available, and no losses were experienced from it under these conditions. This leads to the assumption that cattle do not begin to eat the rattle-weed as long as there is sufficient other forage on the range.

The most effective means of avoiding losses from rattle-weed, unless eradication is practicable, appear to be to avoid grazing the range too closely and to feed susceptible stock.

OTHER CAUSES OF LOSS OF STOCK ON THE RANGE.

Some other causes which contribute to the aggregate losses on southern New Mexico ranges are predatory animals, accidents which may or may not be avoided, and grazing horses and mules on the same range with cattle.

Coyotes cause occasional loss among young calves, but such losses occur mainly when cows are too weak to protect their calves. An occasional lobo wolf or mountain lion may cause some loss. The work of the Biological Survey of the United States Department of Agriculture in eradicating these animals has been a very important factor in decreasing losses from this cause, and with continued activities of this bureau such losses should eventually become negligible.

Weak cows are sometimes lost in spring from getting stuck in bog holes. Such places should be fenced or watched to see that weak cattle are kept away and that any cows that may have become bogged down are pulled out.

Horses and mules will often stampede around watering places and run over and injure weak cattle and sometimes kill young calves. If it can be avoided, this class of stock should not be allowed among weak cows or those with young calves.

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[26] Imes, Marion, "Cattle Lice and How to Eradicate Them," U. S. Dept. Agr., Farmers' Bul. 909, February, 1918. Also, "The Spinose Ear Tick and Methods of Treating Infested Animals," U. S. Dept. Agr., Farmers' Bul. 980, May, 1918.

[27] Rattle-weed loco=*Astragalus allochrous;* blue woolly loco=*Astragalus bigelovii.*

TOTAL LOSSES ON THE JORNADA RANGE RESERVE.

Losses from all causes among all classes of stock on the Jornada Range Reserve since July 1, 1915, were 1.9 per cent on a basis of the full year up to December 31, 1915, 1.5 per cent in 1916, 1.8 per cent in 1917, 3.5 per cent in 1918, and 1.5 per cent in 1919, or an average annual loss of 1.9 per cent.

Reports received from stockmen in connection with the investigations of live-stock production in the 11 far western States in 1914 showed avarage annual losses for New Mexico as follows: Calves up to 12 months of age, 10.6 per cent; yearlings, 5.6 per cent; stock over 2 years old, 5.8 per cent; an average of 7.2 per cent from all causes.[28]

The estimated losses for southern New Mexico since 1914 were: 10 per cent in 1915, 12 per cent in 1916, 15 per cent in 1917, 35 per cent in 1918, and 5 per cent in 1919, or an average annual loss of 16.7 per cent for the 5-year period. The Cattle Sanitary Board of New Mexico estimates the losses for the whole State to have been 25 per cent of all the cattle in the State during the drought and severe winter of 1918–19. While these figures include some losses from other causes, they are principally due to starvation.

The results on the Jornada Range Reserve to date in reducing losses from starvation, blackleg, and other causes justify the serious consideration of stockmen. This is especially true under the existing conditions of increased cost of range, labor, equipment, and supplies, and poor credit with high rate of interest on loans to finance the business.

INCREASING GROWTH OF YOUNG STOCK.

Young stock do not make much gain in weight on southern New Mexico and similar ranges from December until the time green grass comes in the following summer. Successive weighing of steers in November and December, when they are 18 months of age, and in May or June, at 24 months of age, show little or no gain in weight during the six-months period. This stunting makes young stock slow to respond in growth when green grass comes. As a result, yearling or two-year-old steers from these ranges are not fit to go to the feeders, but find their market mainly as stockers to go to northern pastures for one or two years' maturity. As stockers for this purpose they do not bring a very high price in comparison with prices received for stock of the same age from other sections.

The stunting of young stock is even more pronounced during drought. As has already been stated, yearlings from southern New Mexico during the drought of 1916–1918 were often 100 pounds under their average weight, resulting in heavy "cut back" by

[28] Barnes, Will C., and Jardine, James T., Meat Situation in the U. S., Part II, U. S. Dept. Agr. Sec. Rept. 110.

buyers and lower prices for those taken. This cut-back in 1917 and 1918 varied from 10 to as high as 50 per cent of yearlings offered for sale. Prices paid for yearling steers have not advanced in New Mexico since 1916, in spite of some improvement in grade, while there was marked advance in prices paid for this class of stock elsewhere from 1916 to 1919. According to information furnished by the Cattle Sanitary Board of New Mexico, the maximum average high price has been $40 since 1915, while the average minimum price has dropped from $39 per head in 1916 to $25 in 1918 and 1919. This lack of increase in price is traceable to the lack of growth in young stock in time of drought. Young heifers, too, did not make normal growth, and while fewer of these are sold, they are often set back so that they are not in fair breeding condition.

Eliminating the period of no growth, or having young stock in condition to respond quickly and make more rapid growth after feed comes, would mean a higher price for the steers to go as stockers to northern pastures, and possibly would produce a steer that would go direct to the feeder. Improvement along this line is important to obtain maximum returns from the attention and expense required to grow better-grade stock.

SELLING STEERS AND SURPLUS HEIFERS AS CALVES.

Selling steers and surplus heifers as calves in the fall would eliminate carrying them over the most expensive period of the year. The better grade of stock similar to that now being raised on the Jornada Range Reserve should find a ready market as calves among feeders in the farming States. This practice will be largely limited by two factors—lack of uniformity in age of calves in the fall and the necessity of holding over stock to consume surplus forage not needed by the breeding herd.

The breeding season on Southwestern ranges is ordinarily considered yearlong, and as a result, calves are dropped throughout the year, although mainly from March to July. Consequently, a large number of calves too young to sell in the fall must be carried through the winter and sold the following year. Restricting the breeding season to a certain period of the year would result in more uniformity in size of offspring at time of sale.

Selling most of the steers and surplus heifers as calves, however, will not leave sufficient stock on a range to consume surplus forage in good years, an essential part of range management where drought occurs. In such cases the practicability of selling calves will depend upon the grade of stock being raised. If the greatest profit from good grade stock may be obtained by marketing the product as calves it may be advisable to sell the calves raised each year and in good years when there is surplus forage purchase cheaper steers.

In either case, whether selling as calves or holding over until yearlings, there will be a number of young stock, including heifers retained to replace culls in the breeding herd, which will be carried over the dry period from November until July the next year. Maintaining the growth of such stock over this period, or at least having them in condition so that they will respond quickly when the green grass comes, should make such stock grow out better and heifers mature earlier for the breeding herd.

SUPPLEMENTAL FEEDING OF YOUNG STOCK.

Feeding the young stock a small amount of cottonseed-cake or meal to supplement the native forage and make it a better growing ration from late fall until rains occur the following spring or summer should result in eliminating the dormant period in growth of calves and yearlings at this time. At least, the young stock should be in condition to start growth sooner and make more rapid gains when green feed does come. The benefits from feeding early weaned calves a small ration of cottonseed cake during this period on the Jornada Range Reserve in 1916, 1917, and 1918 have demonstrated that it is a practicable undertaking with that class of stock. Feeding a number of two and three-year-old steers several pounds of cottonseed cake per day while on grass in 1914 and 1915 indicated that it was not practicable to try fattening steers for the market in this way; for bringing them into condition suitable for feeders it was considered a success. As better grades of stock are raised this procedure may be practiced with even greater success, and the Southwestern breeder will eventually establish a better market for his product than is now available.

FUTURE PLANS FOR THE JORNADA RANGE RESERVE.

Plans for the future on the Jornada Range Reserve include selling the best steer calves in the fall to feeders in the corn belt, if possible, and feeding all young stock retained three-fourths to 1 pound of cottonseed cake per day for 90 to 120 days in the spring to keep them growing during this period. Results to date in feeding seem to justify such practice. With the increased cost of handling and producing stock in general every opportunity for increasing the profit is worthy of consideration and trial.

In choosing the most desirable plan, the main object and one that Southwestern producers should bear in mind, however, is to produce the kind of animal for which there is greatest demand and that the best range and feeding facilities will permit.

SUMMARY.

Periodic droughts causing heavy losses, low calf crops, and interference with building up of herds are the chief set-backs to the cattle

industry in the Southwest at present, and one of the biggest problems of the industry to-day is to overcome these unfavorable conditions. Rainfall records over a long period of years and experience of stockmen during the past two or three decades indicate that droughts of 3 to 4 years' duration may occur in each cycle of 8 to 10 years.

A study made in southern New Mexico showed that on grama-grass range drought alone if prolonged beyond the second year killed 40 per cent of the best grazing plants and reduced the quantity of forage produced approximately 50 per cent. Grazing tends to increase the effect of drought to a degree varying with the time and amount of use, but when limited during the main growing season—July, August, and September—to from 30 to 50 per cent of the proper yearly rate, it has no harmful effect. The reduction in grazing at that time does not interfere with full use of the range, since the grass cures and is valuable for winter range. To restore damaged grama-grass range to its former condition of productivity will probably require several years of judicious handling.

In the case of tobosa grass or similar range there is less dying out of the forage but the amount of feed produced varies more directly with the amount of rainfall, so that the reduction in time of drought is about the same as for grama grass. Tobosa grass is not easily injured by grazing during the growing season and is of little value for grazing after it dries up, so that it is well adapted to summer grazing.

Drought has a direct influence upon the carrying capacity of the range. Data obtained thus far indicate that range with a grazing capacity of 27 acres per cow per year will only carry stock at the rate of 32 acres per head the first year of drought, 45 acres the second, 54 acres the third, and 54 the fourth.

Cattle raising, to be successful under such conditions, must be adjusted so that the number of animals will conform to the carrying capacity of the range in time of drought. In other words, there should be a reduction to 85 per cent of the original number the first year, to 60 per cent the second, and to 50 per cent the third.

Since the Southwest is primarily a breeding section, and it is difficult to dispose of breeding cows upon short notice, the breeding herd should be confined to what the range will carry in poor years or to 50 per cent of the carrying capacity during good years. The surplus forage in good years may be utilized profitably by holding over or buying young steers or heifers to be disposed of in time of drought to make all range available for the breeding cows. The age, number, and class of such stock to carry will depend upon the forage not needed for the breeding cows and the market.

Division of grama-grass and tobosa-grass types of range, when the two occur together on a range unit, and using the former in winter

and the latter in summer will serve the twofold purpose of giving the grama grass the opportunity it requires to maintain itself on the range and of securing the maximum use of the tobosa-grass range. At the same time, it reserves a supply of range for use by the stock during late winter and until rains occur in the early summer, a period when stock on the range are always poorest. Where a range is all grama grass or similar type of range, the desired result may be obtained by deferring grazing on a portion of the range during the growing season and using it late in the year, and then rotating the system to each part of the range successively.

Proper distribution of stock for full and even utilization of the range may best be secured by adequate watering facilities, proper salting of stock, and riding. Permanent watering places should not be more than 5 miles apart on the range where the carrying capacity of the range will justify it. Stock should have plenty of salt at all times, and the salt should be placed where it is desired the stock should graze. Riding after stock to keep them on the proper range assists further in good distribution.

Increased cost of production will best be offset and returns from the industry increased through improving the grade of stock, raising a larger percentage of calves, and reducing the losses from the various causes.

The grade of stock may best be improved by use of purebred bulls, culling the poorer grade cows, and replacing them with the best grade heifers obtained as a result of the use of good bulls. Slightly better bulls should be obtained every few years to continue building up the herd.

Twenty-two to thirty-three more calves per 100 cows than the present average for southwestern range conditions have been obtained over a period of four years where better care and attention were given the breeding herd. Keeping cows and bulls in good breeding condition, adequate distribution of bulls, segregation of nonbreeding stock, especially during the breeding season, and breeding no cows under 20 months or over 12 years of age, are mainly responsible for the good results. Of these, the condition of the cows and distribution of bulls are by far the more important. Having a sufficient amount of winter range, supplemented with three-fourths to one and a half pounds of cottonseed cake per day from approximately February until spring or summer rains occur, will keep cows in shape to mother their calves properly and to breed again the following summer. Early weaning of her calf gives the cow the advantage of being dry longer before dropping the next calf.

Employment of range riders to keep bulls distributed among the cows is essential to secure proper bull service when stock are in comparatively large pastures. One rider can easily keep the bulls dis-

tributed among 500 cows when range is not rough and 4 bulls per 100 cows are used. A few cows with a single bull in a small pasture also secures efficient bull service.

The heavy losses from starvation in time of drought may be avoided by adjusting the number of stock to what the range will carry. The heavy loss during the usual critical period of the year may be prevented by reserving a supply of winter range for use during that period, avoiding long distances between feed and water, and feeding a small percentage of the poorest cows.

Supplementing the range forage with a small amount of some concentrated feed, such as cottonseed cake, will usually save the weak cows that otherwise would perish.

Chopped soapweed may be fed to advantage when the forage is getting short.

Early weaning of calves and careful handling of stock, including segregation of the weakest cows, are also important points in reducing losses. The extra care and feed will pay for itself in cattle saved.

Losses from blackleg may be made almost negligible by prompt vaccination. Dipping is effective in keeping stock free of scabies and lice.

The low price received for steers from the Southwest as compared with those from other localities is due mainly to the stunting in growth when the feed on the range is dry, from early winter until rains the following summer. Feeding a small amount of cottonseed cake or some such feed should aid materially in keeping the young stock growing over this period and cause them to respond quickly to green grass when it comes.

LIST OF PUBLICATIONS RELATING TO THIS SUBJECT (ARRANGED CHRONOLOGICALLY).

Div. Agros. Bull. 16, Grazing Problems in the Southwest, by J. G. Smith. 1899.

Bur. Plant Indus. Bull. 4, Range Improvement in Arizona, by David Griffiths. 1901.

Bur. Plant Indus. Bull. 67, Range Investigations in Arizona, by David Griffiths. 1904.

Bur. Plant Indus. Bull. 117, The Reseeding of Depleted Range and Native Pastures, by David Griffiths. 1907.

N. Mex. Agr. Expt. Sta. Bull. 66, The Range Problem in New Mexico, by E. O. Wooton. 1908.

Bur. Plant Indus. Bull. 177, A Protected Stock Range in Arizona, by David Griffiths. 1910.

Ariz. Agr. Expt. Sta. Bull. 65, The Grazing Ranges of Arizona, by J. J. Thornber. 1910.

Proc. Soc. Amer. For. VII: 160–7, 1912. Range Improvement and Improved Methods of Handling Stock in National Forests, by J. T. Jardine.

N. Mex. Agr. Expt. Sta. Bull. 81, The Grasses and Grasslike Plants of New Mexico, by E. O. Wooton and P. C. Standley. pp. 176, 1912 (iss. December, 1911).

Farmers' Bulletin 578, The Making and Feeding of Silage, by T. E. Woodward et al. Revised 1920.

Farmers' Bulletin 592, Stock-Watering Places on Western Grazing Lands, by Will C. Barnes. 1914.

Journ. Agr. Res. iii: 93–147. 1914 (Nov. 16). Natural Revegetation of Range Lands Based upon Growth Requirements and Life History of the Vegetation, by A. W. Sampson.

U. S. Dept. Agr. Bull. 211, Factors Affecting Range Management in New Mexico, by E. O. Wooton. 1915.

The National Wool Grower for Oct., 1915. Deferred and Rotation Grazing, by L. H. Douglas.

Bur. An. Indus. Circ. 31 (6th rev.), Blackleg: Its Nature, Cause, and Prevention, by V. A. Norgaard and J. R. Mohler. 1915.

U. S. Dept. Agr. Y. B. Sep. 678, Improvement and Management of Native Pastures of the West, by J T. Jardine. 1916 (from 1915 Yearbook).

U. S. Dept. Agr. Bull. 367, Carrying Capacity of Grazing Ranges in Southern Arizona, by E. O. Wooton. 1916.

U. S. Dept. Agr., Sec. Rept. 110, Meat Situation in the U. S., Part II. Live Stock Production in the Eleven Far Western Range States, by Will C. Barnes and James T. Jardine. 1916.

U. S. Dept. Agr. Bull. 588, Increased Cattle Production on Southwestern Ranges, by James T. Jardine and L. C. Hurtt. 1917.

U. S. Dept. Agr. Bull. 700, Climate and Plant Growth in Certain Vegetative Associations, by Arthur W. Sampson. 1918.

N. Mex. Col. Agr. and Mech. Arts, Bull. 113, Climate in Relation to Crop Adaptation in New Mexico, by Charles E. Linney and Fabian Garcia. 1918.

Farmers' Bulletin 980, The Spinose Ear Tick and Methods of Treating Infested Animals, by Marion Imes. 1918.

Farmers' Bulletin 909, Cattle Lice and How to Eradicate Them, by Marion Imes. 1918.

Farmers' Bulletin 1017, Cattle Scab and Methods of Control and Eradication, by Marion Imes. 1918.

U. S. Dept. Agr. Farmers' Bull. 1017, Cattle Scab and Methods of Control and Eradication, by Marion Imes. 1918.

U. S. Dept. Agr. Bull. 745, Chopped Soapweed as Emergency Feed for Cattle on Southwestern Ranges, by Clarence L. Forsling. 1919.

U. S. Dept. Agr. Bull. 790, Range Management on the National Forests, by James T Jardine and Mark Anderson. 1919.

U. S. Dept. Agr. Bull. 791, Plant Succession in Relation to Range Management, by Arthur W. Sampson. 1919.

Farmers' Bulletin 1179, Feeding Cottonseed Products to Live Stock, by E. W. Sheets and E. H. Thompson. 1920. (Some references to feeding in the Southwest.)

Farmers' Bulletin 724, Feeding Grain Sorghum to Live Stock, by G. A. Scott. Revised 1921.

Farmers' Bulletin 1167, Essentials of Animal Breeding, by George N. Rommel. 1920.

U. S. Dept. Agr. Bull. 905, Principles of Live-Stock Breeding, by Sewall Wright. 1920.

U. S. Dept. Agr. Bull. 827, The Cut-over Pine Lands of the South for Beef-cattle Production, by F. W. Farley and S. W. Greene. 1921.

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